

BASIC RESULTS OF THE MEDICAL RESEARCH CONDUCTED DURING THE
FLIGHT OF TWO CREWS ON THE SALYUT-5 ORBITAL STATION

Anonymous

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16. Abstract The study of the effect of space factors, especially weight- lessness, on man, taking into account prophylactic measures and devices to counteract that effect was part of the program for 2 flights on the Salyut-5 orbital station. Information from the equipment on board was transmitted telemetrically including: an electrocardiogram; a sphygmogram of carotid and femoral arteries; a kinetocardiogram; a tacho-oscillo- gram of the humeral artery, perimetric oscillations of the femur, venous pulse and pressure in the jugular veins, vital capacity of the lungs, respiration rate and lung ventilation. Stress factors, metabolism, biological and bacteriological and other tests were included. A comparison was made between these data and pre and postflight test results.					
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Translator's Notation: Abbreviations and acronyms used in the text

AMo	--	Mode amplitude
AOP	--	Antiorthostatic position
AP	--	Arterial pressure
CDR	--	Commander
DI	--	[Diastolic index] ¹
FCC	--	Frequency of cardiac contractions
HP	--	Horizontal position
IE	--	Isoenzyme
IIOS	--	Integral index of orthostatic stability
IPS	--	Inflatable prophylactic suit
LBNP	--	Lower body negative pressure
LDH	--	Lactic dehydrogenase
MV	--	Minute volume
OBE	--	On-board engineer
OP	--	Oxygen pulse
OES	--	Orbital planetary station
OS	--	Orthostatic stability
PC	--	Phosphocreatinase
PE	--	Expulsion period
PFPS	--	Postflight prophylactic suit
REG	--	Rheoencephalograph
RPPW	--	Rate of propagation of the pulse wave
RR	--	Respiration rate
SDH	--	Sorbitodehydrogenase
SI	--	Stroke index
SPR	--	Specific peripheral resistance
StI	--	Stress index
SYL	--	[Stroke volume]
SyI	--	[Systolic index]
VC ₂	--	Volume of CO ₂
Ve	--	Elastic vessels
Vm	--	Muscular vessels
VO ₂	--	O ₂ requirement

¹ [] indicate that the acronym was not defined in the text or in reference materials, but probably stands for that term.

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According to the Soviet program for mastery of near-earth cosmic space in 1966-77, flights of two crews were made on the Salyut-5 orbital station: /1*

- from July 6 to August 24, 1976, a 49-day flight of a crew made up of crew commander B.V. Volynov and on-board engineer V.M. Zholobov;

- from February 8 to 26, 1977 - an 18-day flight of the crew made up of commander V.V. Gorbatkov and on-board engineer Yu.N. Glazkov.

The program of both flights had a broad scientific character. It was set up with a large number of varying experiments intended to solve scientific and national economy problems. One of the sections of this program was the study of the effect on man's organism of factors of space flight taking into account the use of a complex of measures directed at preventing the adverse effects of weightlessness.

The arsenal of devices and methods used in the Soviet space programs for prophylaxis of adverse changes in the organism due to weightlessness as one of the leading physical factors of space flight, is basically defined at the present time. These devices and methods have already been used earlier with a positive effect during preceding flights on the Salyut type orbital stations.

On the Salyut-5 station, a complex of devices and methods indicated included:

- a complex training mock-up for physical exercises ("a running track," a collection of spandrel frames, a system for creating axial load, etc.);

- load suits for constant wearing; /2*

- vacuum capacity for creating negative pressure on the lower half of the body;

*Numbers in the margin indicate pagination in the foreign text.

- on-board first aid kit;
- post-flight prophylactic suit (FPS)

Daily operative medical control and periodic medical examinations and studies are planned for the program of medical supervision of these flights as for flights on other orbital Salyut type stations.

Operative (current) medical control for the general condition and state of health of the cosmonauts is accomplished using telemetric methods, and also on the basis of data of radio exchange and televised observations. The following were transmitted to the ground measuring posts: electrocardiograms at D-S contact point (side-side), seismocardiograms, breathing rate and temperature of the body (submuscular). According to the program, both cosmonauts had to be constantly hooked up to the equipment continuously during the first three days of flight; later on, the cosmonauts were attached to the apparatus in turn each day, once in 24 hours. Moreover, daily, usually before sleeping, the crew transmitted to Earth a brief report for the preceding day as to their state of health, sleep, appetite, elimination functions, and also data on pulse rate and the size of arterial pressure (measured by the cosmonauts themselves using an ordinary clinical sphygmomanometer).

The periodic medical examinations envisaged recording a broader spectrum of physiological indices, both in the state of operative rest, and during different types of measured load tests. As a rule, these examinations were carried out at the same time of day as in the preflight. For a detailed study of the state of the cardiorespiratory system, an on-board apparatus, the Polinom 2-~~[letters illegible in the text]~~ apparatus was used which made it possible to transmit telemetrically the electrocardiogram with 12 contact points, a sphygmogram of carotid and femoral arteries, a kinetocardiogram, a tacho-oscillogram of the humeral artery, perimetric oscillations of the femur, venous pulse and pressure in the jugular veins, vital capacity of the lungs, respiration rate, breathing volume and breathing minute volume (lung ventilation). /3

Rheographic studies were conducted using a Levkoy apparatus: a rheo-encephalogram, a rheopneumogram.

The following were used as load test effects:

- physical load in the form of a 4-minute run on the "running track" at a rate of 150-160 steps per minute;
- negative pressure on the lower half of the body (LBNP) at a size of 25 mm mercury column for 2 minutes and 35 mm mercury column

for 3 minutes.

Moreover, the program of scientific and medical research envisaged periodic:

- taking and saving of a sample of capillary blood (from the palm) for subsequent analysis in ground conditions (postflight);
- measurements of the body mass on the on-board instrument with telemetrically transmitted indices to Earth;
- determining taste sensitivity and the pH of the saliva; and also conduct of certain psychophysiological studies.

In this way, the volume of medical observation and medical research made it possible to discover changes occurring in the organism of the cosmonauts due to physical factors of flight and the complex on-board devices made it possible to correct these changes.

Preventing possible adverse changes in the general condition and general work capability of the crew was accomplished [words illegible in the original text], regulated regime of work, rest and eating periods. /4

The planned schedule for the station envisaged:

- an 8-hour uninterrupted sleep for both members of the crew at the same time;
- self-service operations - 8 hours including:
 - physical training - 2 hours 30 minutes
 - taking nourishment - 2 hours 15 minutes
 - personal hygiene - 30 minutes
 - personal time - 2 hours 45 minutes
- work - 8 hours.

In accordance with medical recommendations directed at maintaining high work capability of the crewmembers and timely restoration of strength after stressful activity, the time devoted to controlling the spacecraft and its systems, carrying out various experiments and observations (including the medical research) and each professional activity, that is, the total budget of working time amounted to from 42 to 48 hours a week with one free day. This free day or rest day for the cosmonaut made it possible for him to do as he pleased except for operations necessary for

maintaining the work capability of the station and certain medical studies.

Comfortable conditions for living and work of the cosmonauts were maintained for the entire flight on the station.

The hygienic parameters of the station atmosphere were:

- total barometric pressure P_{tot} - 830 - 870 mm mercury column
- partial pressure of oxygen pO_2 - 169 - 210 mm mercury column
- partial pressure of carbon-dioxide pCO_2 - 1.1 - 9.6 mm mercury column
- humidity - 6.5 - 11.5 mm mercury column
- air temperature - 16° - 26°

In accordance with the results of preceding flights, the caloric intake for the daily ration was reduced to 3000 kcal (2900 - 3100 kcal). Six variations of the daily menu are planned /5 besides the previous four and also reheating was introduced not only for the food tubes and cans but also for the bread; both crews considered this an advantage. According to the wishes of the crew, seasonings of a type of spicy sauce were introduced. They also received a positive evaluation from the cosmonauts.

General Results of the Flight

Carrying Out of the Schedule of the Day

In order to correctly interpret the medical data obtained in the flight and in the postflight period, and also in order to understand the evaluation of the flight by the cosmonauts themselves, it is necessary first of all to know how the cosmonauts worked, that is, to consider the workload of the crew in flight, the planned schedule of the day carried out by them.

One should note that both crews in the initial flight period had difficulties in carrying out the work and rest regime intended before the flight. This involved an increase in time; actually, the time expended by the crews on certain work operations, in comparison with that planned, was increased in the first days of flight in the period of initial adaptation to weightlessness. However, the crews themselves had a noticeable adjustment in fulfilling both the planned obligatory operations and experiments and also the additional reserve operations. Attempting by all possible means to fulfill and sometimes to overfulfill the full program of work resulted in the fact that the crews cut down on

eating time, rest, physical training and even sleep. On some days, the work load of the crews amounted to 13-14 hours; then they also used their personal time which had been set aside according to the schedule for rest, and the free days planned for them were used only partially.

Distribution of time between the basic parts of the work and rest regime and the relationship between the planned and actual time expended are shown in Figures 1 and 2. /6

Insufficient sleep is particularly characteristic of the first crew (Volynov-Zholobov) where the total deficit of sleep for the flight amounted to about 90 hours for each cosmonaut. This apparently also involved the psychological characteristics of the spacecraft commander who possibly made too detailed testing of the condition of the station, making it necessary for him and his flight engineer to lose even more sleep, naturally.

In order to have more time for work, the cosmonauts often put part of their 24-hour food ration in their pockets and ate directly at the work location not interrupting observations and recordings.

Unfortunately, the "savings" in time also cut into the physical training time. This applied particularly to the second crew (Gorbatko-Glazkov) who "expended" their strength on a relatively short flight. They used only 50% of the planned time for physical training.

Work in such a regime, with such high efficiency provided successful completion of the flight program; however, in a definite way it affected the state of health and functional state of the cosmonauts. Noticeable changes in well-being (especially the appearance of feelings of fatigue) and objective shifts in the functional state of the crewmembers had a very clear direct connection to the intensity of preceding activity.

On the whole, the crews themselves understood this. After completion of a flight, the commander and the on-board engineer of the second crew (CDR-2 and OBE-2) unanimously estimated that they could have operated perhaps only for 7-10 days in such a regime. No wonder, in distinction from the first crew, they began to notice fatigue at the end of the working day even in the second day of flight (the first crew - only after a week). /9

Evaluations of Flight by the Crews

The cosmonauts almost uniformly and very similarly to their predecessors described transition to weightlessness and the period of initial adaptation. Each one, of course, had his own peculiarities.

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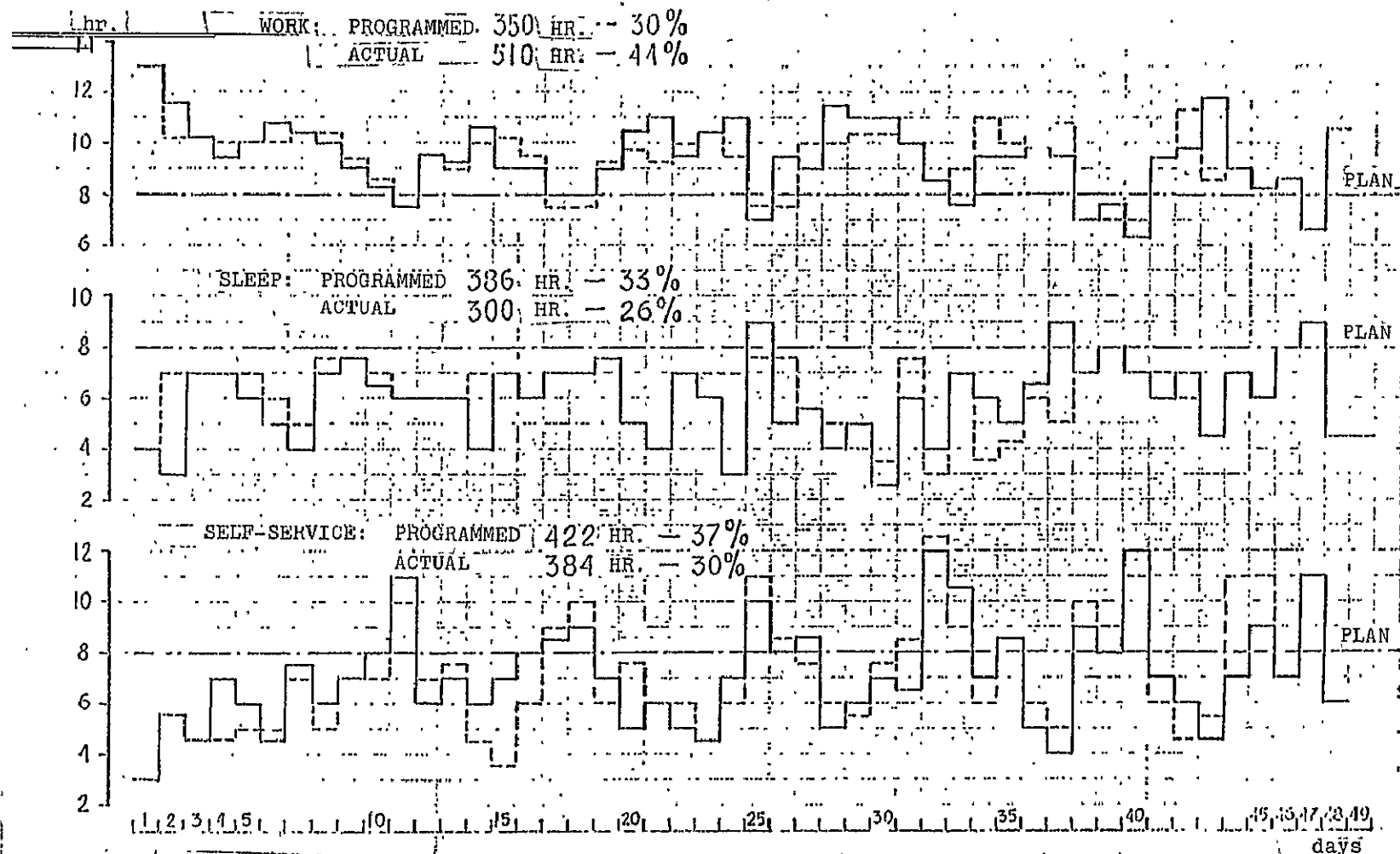
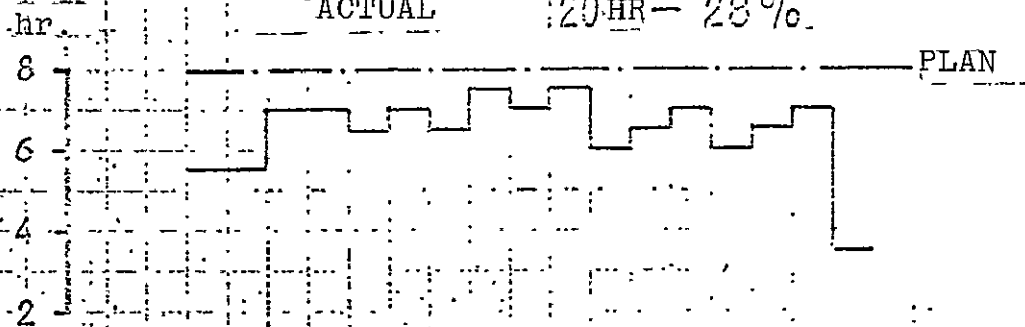
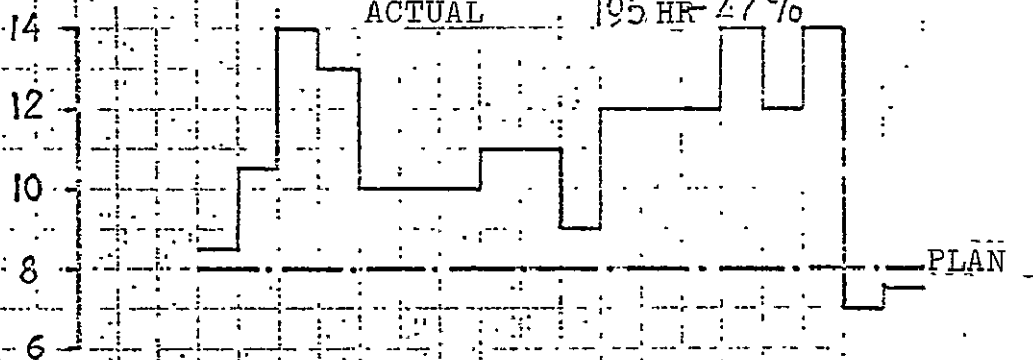


Figure 1. Distribution of time among the basic program elements for the crew of the Soyuz-21--Salyut-5 (total flight time--1158 hours - 100%).

SLEEP: PROGRAMMED 144 HR— 34 %
 ACTUAL 120 HR— 28 %



WORK: PROGRAMMED 136 HR— 33 %
 ACTUAL 195 HR— 47 %



SELF-SERVICE: PROGRAMMED 134 HR— 33 %
 ACTUAL 86 HR— 20 %

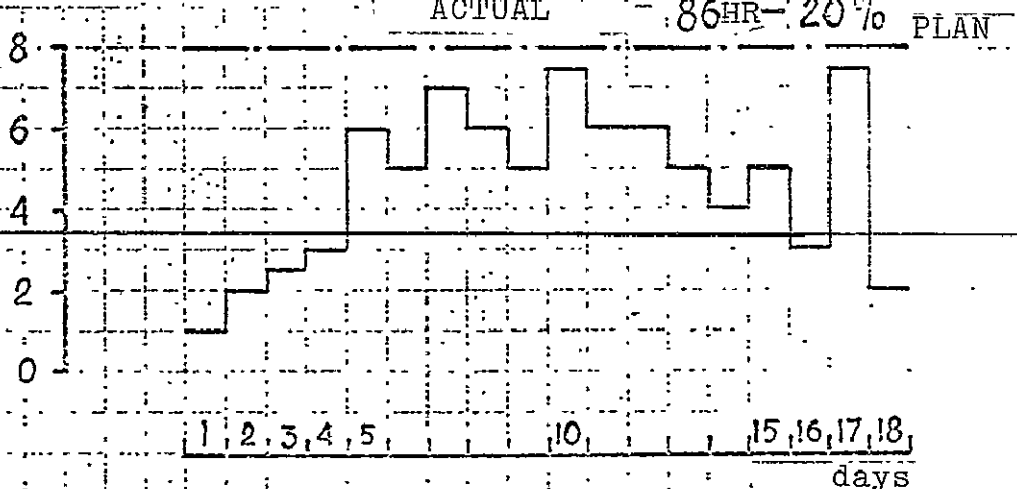


Figure 2. Diagram of distribution of time for the crew of the Soyuz-24--Salyut-5 according to the basic element of the program when making a space flight.
 Total flight time— 414 hr.

Thus, although vestibular dysfunctions, symptoms of motion or rocking sickness did not occur in one of the four, both members of the first crew during transition to weightlessness noted the illusion of perceiving change in position. The CDR-1 felt as if there was a backwards somersault, then the spacecraft (Soyuz) flew in an inverted position; when looking out the porthole at Earth, the illusion of the inverted position disappeared." For the on-board engineer (OBE-1) when going into orbit, "the craft sloped forward at 90°."

It is interesting that the illusions mentioned created a certain amount of difficulty for the crew with manual docking and joining to the station in such a way that it was like the first flights on an airplane in clouds or fog.

The impression is created that, as in other flights, in this case a mutual induction of the crewmembers or a group reaction occurred: both members of the first crew underwent a short-term loss of orientation when transferring from the transport craft to the station and the reverse. The CDR-1 explains this by the fact that on the station "below," the "floor" was located along the length of the axis whereas in the transport spacecraft "below" was perpendicular to it. Therefore, "surfacing" from the launch apparatus of the transport spacecraft "upward" through the orbital section and transition lock to the station, the cosmonaut suddenly seems to be "swimming" over the "floor" of the station, that is, /10 everything has turned by 90°.

It is necessary to point out that earlier such an effect, although less clear, was described only by members of the first crew of the Salyut-4 station, Gubarev and Grechko. But they (and again both of them) perceived a similar vestibular dysfunction only when transferring from the station to the transport spacecraft and this did not occur at all with the reverse transfer.

The second crew OPS of the Salyut-5 (Gorbatko-Glazkov) did not note such illusions.

Both crews, like many other cosmonauts, perceived a rush of blood to the head. The clarity and length of this sensation differed in different cosmonauts.

CDR-1 perceived the rush of blood to the head only weakly, although redness of the face and bulging of the face veins, neck and upper part of the chest was noted. A rush of blood was not accompanied by a headache and did not affect work. The cosmonaut complained only of stuffiness of the nose and slight rhinitis; however, these manifestations may be more due to a slight cold from the ventilator than from the rush of blood.

OBE-1 noted a definite rush of blood to the head, which he began to perceive after 4-5 hours after going into orbit and it gradually increased reaching a maximum on the second day. He had a slight headache. Gradually, the feeling of the head being too full began to slacken and by the fifth day, the cosmonaut stopped noticing it.

In members of the second crew on the other hand, the rush of blood to the head was accompanied by a feeling of "heaviness," and also a headache. These perceptions and the headache lasted fairly long but at the end of the first week they were used to it and stopped giving it attention. Edema of the face and neck was very obvious, especially if one considers that both cosmonauts are round faced and not distinguished by leanness. /11

All of the cosmonauts both in the first and in the second expeditions complained of the dryness of the air. Particularly unpleasant was the sensation of dryness in the nose. The skin became rough. After the flight, the cosmonauts observed a degree of hyperkeratosis during 5-7 days; because of this, removal of thickened sections of skin occurred.

The period of initial adaptation to weightlessness was characterized also by a certain discoordination of motion as had been observed in all preceding flights. Proportioning of effort, coordination of motions with variables were salvaged at the end of the first week of flight.

As was already indicated in both crewmembers, a lack of sleep was noted particularly in the first crew. CDR-1 slept 2-4 hours on certain days. In truth, in these cases he attempted to cut down the time in sleep 1-1.5 hours per day. The sleep usually was very refreshing, the head became clear, fatigue disappeared, and work capability increased.

As to appetite, it remained good in all the cosmonauts. In truth, the first crew noted a change in taste: they stopped eating cheese, its odor irritated them. Moreover, with the development of fatigue at the end of the flight, the appetite of OBE-1 decreased. The food, in general, was satisfying although after intense work and after a good workout on the physical training unit, the crew sometimes added somewhat to the ration from the reserve supplies. In spite of a sensation of dryness in the mouth, not one cosmonaut suffered from thirst, but drank water as usual. /12

The natural elimination functions in all the cosmonauts were regular and caused no difficulties. The stool was usually daily, urine elimination was 4-6 times in 24 hours. Only OBE-2, on the first and second days of flight, was worried that possibly the stool was hard and took a preventative laxative.

Medications were used as needed: for a headache (Analgin, sometimes Bromedole), small injuries, inflammation around the nails (Oxykort ointment), sleep disorders during fatigue (Phenylbut, Eunocin). The use of Etaminal-sodium by the commander of the first crew has already been noted.

Results of Medical Studies

According to the data of operative medical control, changes in the rate of cardiac contractions and elements of the EKG complex at D-S points of contact, corresponded both to observations made in preceding flights and to peculiarities inherent in the cosmonauts and noted in preflight examinations.

The commander of the first crew, B.V. Volynov (CDR-1): horizontal axis of the heart, episodic singular extrasystoles at rest.

The on-board engineer of the first crew, V.M. Zholobov (OBE-1): bradycardia, increase in the time of intra-gastric conductivity to 0.11-0.12 s, calcification of the papilla of the coelices of the right kidney (X-ray discovery) without clinical manifestations and without a disturbance of the kidney function.

The commander of the second crew, V.V. Gorbatko (CDR-2): transitory decrease of the S-T segment and the T wave on the EKG without clinical manifestations and negative dynamics, occasional singular extrasystoles at rest, thickening of mucosa of the walls of both maxillary sinuses without clinical manifestations.

The on-board engineer of the second crew Yu.N. Glazkov (OBE-2): 13 single, occasional extrasystoles at rest.

On the active part of the flight, maximum values of pulse rate were: CRD-1 - 100, OBE-1 - 108, CDR-2 - 132, OBE-2 - 84B/min.

In flight, significant variations in amplitude of the T wave were observed in the CDR-2; sometimes at the end of the day, it decreased becoming 15-17 times smaller than the R wave. Similar manifestations in him occurred before flight and in flight; the variations in size became somewhat greater. It is possible that this was due to the development of compensatory fatigue at the end of the working day.

In the OBE-2, in flight, as in the preflight period, occasionally single extrasystoles were recorded - 3 in the first week of flight and 9 in the next 10 days.

According to the data of statistical processing of dynamic series of R-R intervals (not less than 100 intervals in each block),

characteristic histograms were analyzed: Mode (Mo), amplitude of the mode (AMo), variational peak-to-peak value (ΔX) and stress index ($SI = \frac{AMo}{2\Delta XMO}$).

The high values of the SI which indicate an increase in stress of regulatory mechanisms, were noted in the section of introducing and fulfilling important dynamic operations (approach and docking). The SI values increased also in the evening hours which attested to the stress state of physiological functions and supported statements by the cosmonauts as to feelings of fatigue appearing at the end of the working day.

Periodic more intense examinations of the cardiovascular system and blood circulation as a whole made it possible to evaluate changes occurring in them in more detail.

/14

During most of the examinations of both crews in flight, the final and lateral systolic arterial pressure was higher than pre-flight by 15-20 mm mercury column. (Table 1). In the OBE-1 and OBE-2, also an increase was noted in the mean dynamic pressure at 10-12 mm mercury column.

As it was reported earlier, including in the periodic scientific press, arterial pressure in the crewmembers of the orbital stations of the Salyut type, after a period of initial adaptation, normalized fairly rapidly. Its retention at an increased level during the entire flight for the crew of the Salyut-5 station, should be re-evaluated as a result of high work and emotional stress.

Indices of stroke (SV) and minute (MV) volumes of blood were maintained in flight at the level of maximum preflight values or even somewhat exceeded them. Then, the rate of cardiac contractions in CDR-1 and CDR-2 changed within the limits of preflight values. The FCC increased somewhat in the CDR-1 in 28 days, when a worsening of his condition was observed which was indicated by the MV size.

The OBE-1, obviously, due to the gradual asthenia of the FCC on the second half of the flight, his ordinary indices became noticeably higher.

The rate of propagation of the pulse wave in the aorta (RPPW), as a whole, also had a tendency to increase. This is especially noticeable in the OBE-1.

Changes in blood pressure in the jugular vein are very interesting; this, in the opinion of the researchers, must be an objective index of redistribution of blood in the upper half of the body, an index of the uneven filling of the head with blood, which all the

TABLE 11. [Word illegible in original] INDICES OF BLOOD CIRCULATION IN THE FIRST AND SECOND CREWS OF THE ORBITAL SALYUT-5 STATION.

CREW MEMBER	CONDITIONS OF THE EXAMINATION		FCC beats/min.	ARTERIAL PRESSURE				RPPW m/s	SV ml	MV l
				min.	mid.	lat.	limb			
					mm mercury column					
CDR-1	PRE-FLIGHT	FOR 30 DAYS	54	53	81	103	129	6.8	103	5.6
		FOR 5 DAYS	51	59	85	101	127	4.5	150	7.7
	IN-FLIGHT	6 DAYS	47	54	96	119	146	6.3	157	7.3
		14 DAYS	50	70	96	132	153	6.9	135	6.7
		16 DAYS	48	63	94	125	140	6.1	160	7.4
OBE-1		28 DAYS	56	65	96	126	148	6.5	145	8.1
		44 DAYS	53	67	92	121	147	7.0	118	6.3
	PRE-FLIGHT	FOR 30 DAYS	43	54	82	99	122	5.1	124	5.3
		FOR 5 DAYS	42	46	71	87	104	4.5	136	5.7
	IN-FLIGHT	6 DAYS	40	48	75	109	131	6.5	138	5.5
OBE-2		7 DAYS	41	48	72	100	132	6.6	121	5.0
		13 DAYS	41	51	87	110	137	6.3	134	5.5
		21 DAYS	55	48	-	98	130	6.0	128	7.0
		28 DAYS	51	50	80	106	140	5.8	137	7.0
		40 DAYS	53	42	75	100	122	5.2	166	8.8
CDR-2		43 DAYS	58	57	79	108	132	6.1	121	7.0
	PRE-FLIGHT	FOR 35 DAYS	63	62	96	106	131	6.8	86	5.4
		FOR 3 DAYS	78	69	94	108	146	6.3	83	6.5
	IN-FLIGHT	13 DAYS	69	62	92	109	151	6.2	106	7.3
	PRE-FLIGHT	FOR 35 DAYS	48	56	86	101	126	5.3	116	5.5
OBE-2		FOR 5 DAYS	55	58	86	98	134	5.6	99	5.45
	IN-FLIGHT	8 DAYS	67	60	100	110	120	-	-	-
		12 DAYS	74	57	100	115	147	-	-	-

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cosmonauts talked about. As was reported earlier, in the second crew of the Salyut-4 orbital station, (Klimuk-Sevast'yanov), blood pressure in the jugular vein at 43--44 days of flight, was normalized to a considerable degree and in certain studies it was somewhat lower than the initial. In distinction from these, in the CDR-1 and particularly in the OBE-1, venous pressure remained elevated for the extent of the entire flight. In the second crew, filling of the jugular veins with blood and the pressure in them was also increased, but, it is necessary to take into consideration that the length of their flight was considerably less than the time period when most data noted the appearance of fairly complete adaptation to weightlessness. /16

The appearance of venous stasis in the base of the head was noted in the first crew also, according to the data of focussed rheography with positioning of the electrodes at the frontal-occipital projection. Then, the venous components of the rheogram of the CDR-1 at 46 days of flight, were less clear than at 17 days. In the OBE-1, on the other hand, at 45 days, they increased in comparison with 25 days.

One should note, that in distinction from the CDR-1, in whom, according to the head rheogram, an increase in tonus of the arterial vessels was observed, in the OBE-1, the tonus of arterial vessels of the head at the end of the flight decreased significantly. The decrease in arterial tonus, in combination with the size of venous stasis noted above, is considered less favorable. At the same time, in this period, he began to have headaches.

With a complete electrocardiographic examination, at 19 days of flight, in the CDR-1 at the left chest contact points (Y_4 - Y_6) a shift in the ST segment was observed below the isoline at 0.5-0.8 mm, and also flattening of the T wave which acquired a symmetrical shape. These changes, apparently, can be reevaluated as signs of metabolic disturbance of the myocardium. From the 26th to the 31st days, the changes indicated became more noticeable. We recall that approximately in this period, the CDR-1 noted worsening of his feelings of well-being and undesirable sensations in the heart region. The dynamics of the EKG in the CDR-1 made it possible to [words illegible in the original text] so that he began to develop [word illegible in the original] changes in the myocardium at the end of the flight, although the clarity of their expression was very insignificant. /17

Electrocardiograms of the members of the second crew hardly differed from their preflight electrocardiograms.

A functional sample with the creation of negative pressure on the lower half of the body (LBNP), in the opinion of the

cosmonauts, transferred well in flight; however, members of the second crew evaluated the effect of LBNP as stronger than that on Earth.

Reactions of the cardiovascular system to LBNP in the CDR-1 and CDR-2 were average: the pulse rate increased maximally by 22%, the stroke volume decreased by 39%, arterial pressure was hardly changes (see Tables 18, 20).

In the OBE-1, a sharp decrease in transferability of this sample was noted especially at the end of flight. The rate of cardiac contractions at the time of LBNP in him exceeded the initial by 64%, and the systolic ejection decreased by 63% (see Table 19).

In the OBE-2, reactions to LBNP at 12 days of flight also was clear: the FCC increased by 45%, a decrease in peripheral resistance of the blood vessels and the rate of propagation of the pulse wave according to the aorta was observed (see Table 21).

Studies of the physical work capability (4-minute run on the "running track" at a rate of 160--[word illegible] steps per minute) showed that in the first crew, it was maintained at an adequate level and as the length of flight increased, it did not change significantly. Only at 40 days, in the OBE-1, did one observe signs of a decrease in physical work capability; immediately after running, the rate of cardiac contractions increased by 87%, and the systolic ejections decreased sharply.

Apparently, also reactions to load tests (LBNP and tests with the physical load), in the OBE-1, there was evidence of a gradually increasing asthenia due to the factors and conditions of flight.

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Biochemical studies of blood samples taken during flight and returned to Earth supported the increase in concentrations of urea in the blood observed in previous flights. Changes on the part of the phosphorous fractions of the whole blood were noticeable which can be considered as an indirect indication of unchangeability of the content in the blood of 22,3-phosphoglyceric acid, which has considerable meaning for providing a normal function of the hemoglobin.

Changes in the uniform elements (with ordinary microscopy) and also changes in the blood formula were not observed.

On the orbital Salyut-5 station, first in the Soviet Union, an experiment was carried out in studying the dynamics of change of body weight in space flight.

From the data presented in Table 2, it follows that the

basic loss of body weight, as was true for the American astronauts, develops in the initial stage of space flight; after this, the indices of body weight are maintained at a fairly stable level. Clearer changes in body weight in members of the first crew are, obviously, one of the manifestations of asthenia which developed on a background of fatigue and lack of sleep. Due to the frequent manifestation of headaches in the on-board engineer at the end of the flight, his appetite decreased which also was expressed in a change in body weight.

TABLE 2. DECREASE IN BODY WEIGHT IN FLIGHT (KG)

Crewmembers	Days of flight							
	4	7	13	17	21	30	34	45
CDR-1	-	-	-5.34	-	-4.57	-	-6.19	-6.95
OBE-1	-	-	-2.94	-	-3.2	-2.75	-2.69	-4.42
CDR-2	-1.61	-2.11	-2.67	-2.6				
OBE-2	-2.24	-2.81	-2.59					

An analysis of results of experiments in studying sensitivity of the vestibular apparatus to pulse galvanic current showed that in all the cosmonauts this sensitivity decreases in flight. Taste sensitivity of the tongue was practically unchanged which is supported by the opinions of the cosmonauts as to the food rations and drinking water (evaluations were not made preflight). /19

Completing presentation of medical data of the observations and studies in flight, one should note certain psychological nuances. As has already been pointed out, the crews worked with high efficiency which could lead and actually did lead to fatigue. On such a work background, there had to be high stress and therefore the least disorder of the equipment or imprecision in ground control of the flight caused greater reactions although the cosmonauts attempted to "stay in the framework."

As a result of peculiarities of the sensory background, the monotonous character of the external medium and ecological factors, a compensatory increase in sensitivity to sensory and ecological factors develops (one blows here, there is a noise there, tepid water, uncomfortable attachment, unpleasant color, etc.).

An attempt to solve this conflict situation is carried out by increasing radio exchange with Earth, particularly in transmitting a mass of questions to the control group ("so that those on Earth can also rack their brains," or "in order to inform everyone that it's getting light"). In the first crew, toward the end of the flight, an increased sensitivity was apparent toward evaluation of their work, clear expectation of approval,

praise, and also the desire to complain, "cry on someone's shoulder," although these complaints were presented in a joking manner. At the end of the working day, hypochondric features were apparent. All of this indicated an accumulation of fatigue and the proximity of exhaustion.

/20

Results of Postflight Examinations

The landing of the first crew occurred at night. Before arrival of the search group, the cosmonauts themselves, although with considerable difficulty, got out of the spacecraft, not blowing up their prophylactic suits (IPS). During examination by a doctor of the search group (after 40 minutes) they complained of pronounced weakness, could stand with difficulty only with an inflated IPS. They ate and drank with satisfaction.

The pulse rate immediately on encounter was: CDR-1--96, OBE-1--146, after a 10-minute rests lying down--84 and 86, and in the helicopter going to the base--80 and 84 beats/min; arterial pressure was 150/105 and 110/90 mm mercury column, respectively.

The second crew left the spacecraft also independently and also without using the IPS. During examination at the spacecraft, the pulse rate of the CDR-2 was 98, of the OBE-2--96 beats/min; arterial pressure lying down was 110/70 and 115/75 mm mercury column; submuscular temperature was 37.0° and 36.1°, respectively. Thirst was average.

During examination at the cosmodrome, symptoms of asthenia and fatigue more marked than in the first crew was noted in all the cosmonauts. There was a decrease in the perimeters of the thigh and shin and a large loss of weight (more than any of the other Soviet cosmonauts) in the CDR-1 and OBE-1 (Table 3).

TABLE 3. CHANGE IN BODY WEIGHT AFTER FLIGHT

/21

Crew member	Pre-flight	Deficit on day of landing		Dynamics of weight postflight			
		kg	%	0	4	14	30
CDR-1	78.8	7.3	10.0	71.5	75.5	77.0	78.4
OBE-1	77.0	6.6	9.1	70.4	74.2	75.0	76.9
CDR-2	76.0	3.5	4.6	72.5	74.7	75.5	78.5
OBE-2	65.3	3.9	6.0	61.4	62.8	63.3	64.7

Recovery time for these indices was, as a rule: fairly rapid increase in the first three days postflight and then a slower recovery. By the 14th day, only the CDR-2 had regained.

his weight and by day 30 he even exceeded it by 2.5 kg. In the other cosmonauts, after 14 days, the weight deficit still amounted /22 to from 1.5 to 2.0 kg (OBE-2) and on the 30th day only the OBE-2 had not regained his weight (specially limited diet).

The dynamics for recovery of the perimeters of the thigh and shin were similar: on the 14th day, the deficit amounted to 0.5--1.0 cm in the second crew and 3.0--1.5 cm in the first; by the 30th day, the size of the perimeters had practically regained preflight values and sometimes even exceeded them by 0.2--0.6 cm (OBE-2 and CDR-2).

As has been indicated more than once, such a character of change and recovery of weight and perimeters of the lower extremities indicates that the decrease in weight in flight comes, basically, from loss of water; however atrophic changes of the muscles are important. The latter once again point out the inadequacy of physical load onboard, especially for leg muscles inasmuch as the muscles of the arms have a fairly good load and their characteristics are almost unchanged (Table 4).

It is natural that as in preceding flights, a good deal of attention was turned to a detailed study of the condition of the cardiovascular system.

The general characteristics of frequency of cardiac contractions and arterial pressure at rest with therapeutic examinations after flight are presented in Table 5.

As is apparent from the Table, in the CDR-1, in the first days, obvious hypertension was observed; however, he was the only one capable of standing without the BPS immediately after the flight. The other cosmonauts, in the first hours after landing, could not sit for long much less stand (although they could walk without assistance). Recovery of the indices occurred spasmodically and on the 14th day they had practically returned to preflight levels; however, a certain instability, lability both in pulse and in arterial pressure was observed up to 30 days and possibly longer.

Study of the systemic blood circulation makes it possible /24 to evaluated in more detail a series of indices which characterize the state of the cardiovascular system. The data of this examination presented in Tables 6 and 7 indicate that after flight, in members of the first crew, all of the parameters of arterial pressure were increased including such a stable parameter as mean dynamic pressure (AP_m); the tonus of the elastic and muscle-type vessels (V_m and V_e) and specific peripheral resistance (SPR) were increased. At the same time, cardiac ejection (stroke index--SI) decreased and the period of expulsion (PE) shortened significantly.

TABLE 4. CHANGE IN PERIMETERS OF THE THIGH, SHIN AND SHOULDER

Crew member	Part of the body	Preflight (cm)	Dynamics of the perimeter in post-flight days in cm			
			0	4	14	30
CDR-1	thigh	55.6	-5.7	-3.7	-3.0	-
	shin	35.9	-3.6	-2.7	-1.7	-
	shoulder	29.5	-1.5	-0.1	+0.1	-
OBE-1	thigh	55.4	-3.9	-3.3	-2.2	-
	shin	36.6	-3.5	-1.8	-1.4	-
	shoulder	29.2	-2.3	-0.2	0	-
CDR-2	thigh	52.1	-1.9	-0.9	+0.1	+0.6
	shin	38.0	-2.3	-2.0	-1.0	-0.4
	shoulder	27.6	-0.6	0	+0.1	+0.2
OBE-2	thigh	49.5	-1.5	-1.3	-0.5	-0.5
	shin	34.2	-2.2	-1.8	-0.4	+0.2
	shoulder	26.5	-0.3	0	+0.3	+0.2

Such shifts indicate a certain discoordination of the cardiovascular system, change in its reactivity and transition to another level of functioning with more stress, irrational for ground conditions. /21

In the members of the second crew, changes were less pronounced and they were observed mainly in the CDR-2. In distinction from the members of the first crew, vascular tonus was decreased in the CDR-2 and OBE-2.

Normalization of the cardiovascular system conditions occurred spasmodically. Most of the indices reached preflight values by the 3rd-6th days, but arterial pressure was elevated in the CDR-1 and CDR-2 for 14 days, and the CDR-1 even on the 36th day. Apparently, the changes in regulation of vascular tonus in the CDR-1 caused by asthenia and neurotic stratification, were fairly deep.

The results of studies with different types of load which cause an increase in requirements for the cardiorespiratory system are even more indicative.

Physical Work Capability

On the third day postflight, the first crew underwent a physical load on the bicycle ergometer in a recumbent position. Power was 600 kgm/min at 60+5 rev/min, duration 7 min. Both cosmonauts

TABLE 5. THE DYNAMICS OF FREQUENCY OF CARDIAC CONTRACTIONS AND ARTERIAL PRESSURE AT REST AFTER FLIGHT.

INDICES	POSITION	CREW MEMBER	PREFLIGHT	DAYS AFTER FLIGHT					
				5 (HR.)	1	2	3	6	14
FREQUENCY OF CARDIAC CONTRACTIONS beats/min.		CDR -1	56-60	72	72	72	56	60	60
	LYING	OBE -1	48-50	116	72	60	52	60	50
		CDR -2	70-72	100	84	80	76	80	72
		OBE -2	60-62	100	96	68	64	72	68
	SITTING	CDR -1	60-64	80	80	72	64	64	60
		OBE -1	56-60	120	-	76	76	60	64
		CDR -2	78-80	-	96	84	84	84	80
		OBE -2	62-64	-	108	80	72	96	72
	STANDING	CDR -1	62-64	104	88	88	64	72	-
		OBE -1	68-76	-	-	104	76	100	-
		CDR -2	80-84	-	108	100	92	112	88
		OBE -2	66-70	-	124	92	80	100	80
ARTERIAL mm. mercury column		CDR -1	120/80	130/105	120/80	130/70	120/80	120/80	-
	LYING	OBE -1	115/70	110/90	120/80	118/70	120/70	110/70	-
		CDR -2	105/70	115/85	120/75	105/70	105/70	115/70	115/70
		OBE -2	115/75	115/90	120/80	120/80	115/80	115/75	110/80
	SITTING	CDR -1	120/80	130/120	115/72	140/120	120/88	120/84	120/70
		OBE -1	115/70	100/85	-	118/90	104/76	108/84	110/75
		CDR -2	105/80	-	115/85	100/70	105/70	115/70	120/70
		OBE -2	110/80	-	110/80	110/80	120/80	110/80	110/80
	STANDING	CDR -1	115/80	120/100	130/90	140/90	128/96	130/80	-
		OBE -1	110/80	-	-	110/90	110/80	104/80	-
		CDR -2	105/80	-	120/90	100/80	105/80	110/80	110/80
		OBE -2	110/80	-	105/90	110/85	105/80	100/75	110/80

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TABLE 6. DYNAMICS OF BASIC INDICES OF THE BLOOD CIRCULATION SYSTEM OF THE MEMBERS OF THE FIRST CREW IN CONDITIONS OF OPERATIVE REST IN A RECUMBENT POSITION.

INDICES	CDR-1							LOBE-1						
	PRE-FLIGHT	DAYS AFTER FLIGHT						PRE-FLIGHT	DAYS AFTER FLIGHT					
		I	3	5	7	14	36		I	3	5	7	14	36
FGC	60	59	56	58	66	63	62	49	75	55	60	53	54	43
PE	270	240	280	280	270	260	280	290	230	260	260	275	290	280
AP _{lmb}	135	135	140	145	145	145	145	125	127	135	130	130	130	130
AP _{ps}	110	125	125	125	130	120	120	110	112	125	105	120	105	115
AP _M	85	100	105	90	100	100	98	85	95	100	80	90	85	95
AP _d	70	75	75	75	80	85	80	75	70	80	75	75	63	75
V _m	9.3	11.8	9.3	9.3	9.3	10.8	9.3	6.7	8.8	7.1	7.1	7.1	8.1	7.6
V _e	5.6	9.0	6.3	7.5	6.9	7.5	7.5	5.6	6.4	6.0	6.0	6.0	6.4	6.0
SI	51	34	53	50	55	32	41	46	41	49	34	52	49	45
SyI	3.1	2.0	2.9	2.9	3.6	2.0	2.5	2.3	3.1	2.7	2.0	2.75	2.7	1.9
SPR	27	50	36	31	28	50	39	37	31	37	40	32	31	50

TABLE 7. DYNAMICS OF THE INDICES OF SYSTEMMIC BLOOD CIRCULATION IN MEMBERS OF THE SECOND CREW
IN CONDITIONS OF OPERATIVE REST AND A LYING POSITION

INDICES	CDR-2					COBE-2				
	PREFLIGHT	DAYS AFTER FLIGHT				PREFLIGHT	DAYS AFTER FLIGHT			
		I	3	6	14		I	3	6	14
FCC	77	79	86	99	86	59	88	77	79	65
PE	260	240	250	240	250	260	230	240	230	260
AP	130	130	125	128	145	130	125	130	130	120
AP	110	110	115	110	120	120	115	110	110	110
AP	95	100	95	90	105	100	100	100	100	95
AP _m	75	85	85	75	85	80	85	85	85	75
V _m	9.3	8.6	8.0	9.3	9.3	9.5	9.5	9.5	7.6	9.5
V _e	7.3	6.3	6.3	6.3	7.3	7.5	6.4	7.5	6.0	7.5
SI	37	27	36	42	42	37	33	28	27	34
SyI	2.8	2.2	3.1	3.9	3.6	2.2	2.9	2.1	2.2	2.2
SPR	34	45	31	23	29	45	34	48	45	43

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successfully completed the test, however, with considerably more stress and less efficiency than before the flight: there were higher indices of cardiac contraction frequency, arterial pressure, minute volume of breathing, but then the "oxygen pulse" (OP), on the other hand, was decreased especially in the OBE-1; differing from the commander, the demand for oxygen (VO_2) was decreased during work (see Table 8). In the recovery period, the frequency of cardiac contractions and breathing was also higher but on the other hand the oxygen pulse decreased even more. On the EKG for both cosmonauts, there is a noticeable decrease in the T wave in comparison with the preflight data; for the OBE-1, a pronounced decrease in the size of the T wave in comparison with initial data before the beginning of the study is true. Recovery of pulse and amplitude indices of the EKG was slowed down. /27

A similar decrease in transferability of physical loads was observed in the second crew (Table 9). As an example, let us also introduce the results of a functional test with a 4-minute run on the KTF at a rate of 160 steps per minute which was carried out on the 4th day postflight (Table 10).

As is apparent from the Table, during such a test load, higher FCC were observed, lower sizes of stroke and minute volumes of the blood and delayed recovery of indices after load.

Recovery of physical work capability occurred gradually. On day 6, the level of physical work capability remained practically the same as on day 3. The preflight level was achieved only after 30 days.

Before the flight and for the ten days after flight, the cosmonauts of the first crew were examined for physical work capability using an echocardiograph at the All-Union Cardiological Scientific Center (Table 11). /35

Before flight, there was noted in the CDR-1: average expansion of the cavities of the left ventricle and operative hypertrophy of the myocardium, under load--a decrease in the volumes of the left ventricle (sympathetic stimulation), for a 10-minute recovery--a hypercompensatory phase.

For the OBE-1 preflight, no peculiarities were noted in the myocardium and heart cavity--an increase in the volume of the left ventricle, at 10 minutes--full recovery.

After flight, in both cosmonauts, a decrease in diastolic volume of the left ventricle was observed and an increase in thickness of the wall and mass of the left ventricle. In the OBE-1, also, an increase in the limb-systolic volume, a decrease in stroke ejection and fraction of ejection (systolic and

TABLE 8. CHANGE IN INDICES OF THE CARDIORESPIRATORY SYSTEM DURING STUDIES WITH PHYSICAL LOAD ON THE BICYCLE ERGOMETER (CDR-1 (VOLYNOV, B.V.)).

INDICES	BACK- GROUND	LOAD							RECOVERY			
		1'	2'	3'	4'	5'	6'	7'	2'	4'	6'	10'
I	2	3	4	5	6	7	8	9	10	11	12	13
FCC	56 60	83 85	90 98	88 102	98 103	92 108	90 108	93 110	66 82	59 78	60 69	57 70
RR	14 13	14 10	11 12	14 10	12 13	12 12	12 13	14 14	11 12	10 13	11 14	12 13
MOD	9.9 8.9	17.1 19.0	23.4 21.4	25.4 25.8	26.7 29.7	27.1 28.1	26.7 29.3	28.9 30.7	19.1 18.6	9.8 11.6	10.7 10.5	9.8 10.4
V _{O2}	310 312	496 722	1076 1049	1092 1357	1335 1544	1355 1377	1308 1465	1445 1474	726 707	314 360	353 336	323 385
V _{CO2}	267 258	410 663	983 963	1270 1316	1335 1544	1382 1423	1362 1494	1446 1504	802 781	363 383	332 315	275 322
QP	5.5 5.2	6.0 8.5	12.0 10.7	12.4 13.4	13.6 14.5	14.7 12.7	14.5 13.5	15.5 13.4	11.0 8.6	5.3 4.6	5.9 4.8	5.7 5.5
AP _{1mb}	155 155								155 160	145 160	145 150	135 140
AP _m	75 80								75 80	70 80	70 75	70 75
v _e	750 645								900 565	1113 565	1113 645	900 645

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I	2	3	4	5	6	7	8	9	10	11	12	13
SI	57.0 42.0								39.0 65.0	29.0 80.0	30.0 51.0	37.0 50.0
SyI	3.2 2.4								2.6 4.9	1.8 6.0	1.8 3.6	2.1 3.4
ΣQRS	58.0 59.0	56.0 59.0	54.0 59.0	55.0 62.0	55.0 61.0	56.0 63.0	55.0 61.0	54.0 60.0	55.0 60.0	54.0 61.0	54.0 58.0	55.0 56.0
ΣT	18.0 12.0	17.0 12.0	21.0 14.0	22.0 17.0	19.0 15.0	22.0 14.0	19.0 17.0	20.0 18.0	18.0 17.0	18.0 14.0	18.0 15.0	17.0 14.0
QBE-1 (ZHOLOBOV, V.M.):												
POC	47 59	90 98	90 108	91 113	96 118	96 119	96 122	94 122	55 90	53 81	50 78	52 68
PE	280 260								240 220	280 -	290 -	300 -
RR	11 16	19 17	20 18	19 19	18 19	19 18	18 18	17 19	9 12	9 9	9 10	13 13
MOD	9.5 9.5	11.1 17.5	21.4 22.6	25.8 27.2	26.0 29.5	26.1 27.2	28.0 28.8	28.6 30.1	14.6 15.3	10.4 10.5	8.9 8.2	7.8 7.2
V0 ₂	307 304	344 560	984 949	1342 1197	1326 1239	1306 1142	1372 1210	1373 1234	526 459	281 305	240 262	273 252
VCO ₂	266 247	355 525	899 859	1213 1170	1274 1298	1305 1197	1372 1267	1401 1294	467 536	312 326	231 246	257 223
OP	6.7 5.7	3.8 5.7	10.9 8.7	14.7 10.5	13.8 10.5	13.6 9.6	14.3 9.9	14.6 10.1	9.6 5.1	5.3 3.7	4.8 3.3	5.3 3.7

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I	2	3	4	5	6	7	8	9	10	11	12	13
AP _{1mb}	I30 I40								I50 I45	I40	I35	I30
AP _m	70 80								70 75	70	70	70
y _e	645 565								750 565	645	645	645
SI	42.0 53.0								41.0 55.0	-	-	-
SyI	1.9 3.1								2.5 3.8	3.0	2.5	2.3
ΣQRS	77.0 73.0	82.0 79.0	80.0 83.0	70.0 78.0	74.0 80.0	71.0 78.0	73.0 78.0	74.0 77.0	70.0 77.0	63.0 73.0	77.0 76.0	78.0 69.0
ΣT	28.0 14.0	22.0 3.0	18.0 7.0	17.0 8.0	17.0 7.0	22.0 8.0	18.0 6.0	17.0 7.0	22.0 8.0	20.0 6.0	23.0 8.0	25.0 10.0

NOTATION: UPPER LINE = PREFLIGHT 7/2/1976.

LOWER LINE = POSTFLIGHT 8/27/1976.

TABLE 9. CHANGE IN INDICES OF THE CARDIORESPIRATORY SYSTEM DURING STUDIES WITH PHYSICAL LOAD ON A BICYCLE-ERGOMETER.

INDICES	BACK- GROUND	LOAD							RECOVERY			
		1'	2'	3'	4'	5'	6'	7'	2'	4'	6'	10'
I	2	3	4	5	6	7	8	9	10	11	12	13
			ICDR-2									
FCO ₂	78 72 84	115 121 118	124 133 133	128 143 140	130 147 143	137 147 142	136 146 145	136 149 142	95 111 107	92 104 101	87 100 101	87 98 100
RR	15 10 6	14 15 14	15 17 15	17 19 16	16 19 16	17 16 16	18 15 17	17 17 20	8 9 13	6 13 7	10 12 9	10 9 11
MOD	8.22 7.6 6.3	16.7 15.8 16.3	24.5 25.1 21.8	26.7 33.2 29.9	28.5 33.2 32.3	30.8 34.4 30.8	31.3 36.9 31.4	30.6 36.2 35.1	13.0 17.0 17.0	9.2 12.7 10.3	8.4 9.2 9.35	8.2 9.6 7.8
V _{O₂}	279 264 264	651 521 636	1299 1104 1068	1335 1494 1435	1368 1361 1486	1448 1376 1413	1471 1476 1474	1408 1448 561	494 595 319	322 317 319	286 285 308	262 297 265
VC _{O₂}	221 196 227	518 426 522	980 904 959	1121 1361 1375	1226 1394 1486	1294 1410 1386	1346 1550 1413	1255 1448 1509	507 680 612	331 374 339	277 271 290	221 278 242
OP	3.6 3.9 3.6	5.7 4.3 5.2	10.5 8.3 8.0	10.4 10.4 10.0	10.5 9.3 10.1	10.5 9.4 9.4	10.8 10.1 9.7	10.3 9.7 9.9	5.2 5.3 5.0	3.5 3.1 3.0	3.3 2.8 3.0	3.0 3.0 2.7
AP _{cs}	120 135 130								150 145 -	140 140 -	135 140 140	125 130 130
AP _d	75 80 88								70 80 -	70 75 -	70 80 85	75 80 85

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I	2	3	4	5	6	7	8	9	10	11	12	13
ΣQRS	52 62 59	57 62 62	56 59 61	56 56 59	57 54 59	60 54 62	60 62 63	59 62 54	56 62 55	57 60 59	55 60 59	50 60 67
ΣT	7.5 8 6	10 9 7.5	14 10 10	11 9 10	12 8.5 9	11 9 8.5	10 8 7.5	10 7 8	5 7 8.5	5 4 4.5	5 4 4.5	5.5 5.5 5
OBE-2												
FCC	78 63 76	116 117 119	119 135 137	126 143 145	132 150 149	135 152 156	139 155 159	140 156 160	112 112 122	97 102 107	94 97 98	88 91 94
RR	11 13 11	14 18 16	17 18 16	18 17 15	18 18 17	16 18 16	17 17 17	18 18 17	14 12 16	13 14 12	11 12 10	10 13 10
MOD	6.4 6.5 5.7	13.6 12.2 14.1	20.8 22.8 23.9	26 28.3 27.7	28.9 29.5 28.1	28.7 31.6 31.0	29 30.3 31.0	28.6 31.7 29.2	17.5 13.9 15.9	10.8 11.0 9.9	8.5 8 7.5	6.9 6.9 6.9
VO ₂	234 218 205	544 502 538	1144 1122 1099	1326 1387 1302	1145 1327 1292	1440 1422 1364	1479 1363 1395	1459 1458 1314	578 542 541	313 352 307	272 256 247	242 214 248
VCO ₂	196 182 159	435 457 423	874 1000 956	1170 1387 1246	1329 1445 1292	1354 1517 1426	1363 1424 1441	1316 1522 1343	665 598 588	346 374 297	264 256 217	207 186 207
OP	3.0 3.4 2.7	4.7 4.3 4.5	9.6 8.1 8.0	10.5 9.7 8.9	10.9 8.9 8.7	10.8 9.3 8.7	10.6 8.8 8.7	10.4 9.4 8.2	5.2 4.8 4.5	3.2 3.4 3.0	2.9 2.6 2.5	2.8 2.3

I	2	3	4	5	6	7	8	9	10	11	12	13
AP _{1mb}	135 135 125								155 155 160	150 140 140	135 130 130	135 135 125
AP _h	75 90 90								80 95 80	80 90 80	80 80 85	75 90 85
V _e	- 7.5 6.4								- 5.6 6.4	- 7.5 6.4	- 5.6 6.4	- 7.5 6.4
ST	- 33 28								- 30 32	- 25 38	- 47 34	- 33 32
SyI	- 2.3 2.3								- 3.2 3.6	- 2.5 3.8	- 4.3 3.3	- 3.0 2.8
ΣQRS	58 54 52	48 47 52	50 53 47	51 47 53	56 50 53	52 50 52	54 53 52	55 47 65	57 54 53	57 54 53	57 56 52	57 54 52
ΣT	20 26 20	15 14 9	18 18 13	17 17 15	19 19 11	16 20 12	18 18 12	15 17 13	13 19 16	15 15 11	16 16 12	20 20 16

NOTATION: FIRST LINE = PREFLIGHT INDICES, SECOND = DAY 3 POSTFLIGHT, THIRD = DAY 6 POSTFLIGHT.

TABLE 10. DYNAMICS OF FCC, STROKE AND MINUTE VOLUMES OF BLOOD DURING A FUNCTIONAL TEST ON

	BACKGROUND			RUN				RECOVERY							
	-2'	-1'	-30"	1'	2'	3'	4'	10"	20"	30"	1'	1.5'	2'	3'	4'
				CDR-2											
FCC	83 100	84 107	86 101	114 150	123 153	126 156	120 150	110 145	113 143	100 130	93 124	92 111	98 115	101 109	101 104
SV	60 36	58 37	60.5 34	-	-	-	-	67 35	60 38	64.6 29	46.6 29	49.5 32	45.6 31	46.4 33	51.8 31
MV	5.01 3.66	4.9 3.98	5.2 3.41	-	-	-	-	7.38 5.17	6.74 5.46	6.47 3.81	4.35 3.6	4.57 3.58	4.47 3.54	4.7 3.6	5.23 3.18
				OBE-2											
FCC	71 78	60 79	65 83	126 147	138 159	138 162	135 150	151 163	- 156	128 151	94 125	- 117	63 118	68 111	71 105
SV	59 29	62 32	63 26	-	-	-	-	49 35	- 430	46.4 30	42 20	- 22	60.6 17	50 20	49 17
MV	4.12 2.29	3.75 2.56	4.09 2.19	-	-	-	-	7.38 5.69	- 4.61	6.08 4.51	3.95 2.53	- 2.58	3.83 1.99	3.39 2.23	3.48 1.77

UPPER LINE -- PREFLIGHT; LOWER -- POSTFLIGHT

TABLE 11. RESULTS OF ECHOCARDIOGRAPHIC EXAMINATION WITH MEASURED PHYSICAL LOAD.

	INITIAL STATE	LOAD			RECOVERY	
		300X·3'	600X·3'	900X·3'	5 MIN.	10 MIN.
CDR-I						
FCC	57 65	75 88	90 96	103 116	65 80	60 76
AP	135/80 130/80	160/85 150/80	200/75 180/80	220/95 220/80	140/75 145/78	130/80 135/80
SV	125 106	116 86	103 83	98 83	92 94	94 109
FRACTION OF EJECTION	67 72	75 69	79 70	83 70	51 70	59 74
MV	7.125 6.89	8.7 7.568	9.27 7.968	10.09 9.628	5.98 7.52	5.64 8.284
OPCC	1103 1121	1010 1091	1006 1137	1082 1051	1292 1066	1370 949
OBE-I						
FCC	56 60	75 92	100 112	115 150	73 84	60 76
AP	130/80 115/70	145/75 130/70	180/50 160/75	200/40 190/80	135/80 118/75	135/80 118/75
SV	119 85	127 97	132 92	138 114	99 130	115 123
FRACTION OF EJECTION	69 58	63 54	68 38.5	80 45	57 62	59 74
MV	6.664 5.1	9.525 8.924	13.2 10.304	15.87 17.1	7.227 10.92	6.9 9.348
OPCC	1160 1332	825 806	565 801	470 545	1087 654	1139 764

NOTATION: UPPER LINE - PREFLIGHT, LOWER LINE - POSTFLIGHT.

diastolic dilations of the left ventricle, decrease in contractile capability of the myocardium) were observed. Moreover, an increase in the left auricle, a decrease in amplitude and rate of motion of the mitral valve were observed. According to the results of echocardiographic studies, one can conclude that as a result of space flight, the cosmonauts developed diffusive changes in the myocardium, a decrease in tonus of the cardiac muscle and contractile capability of the myocardium.

Echocardiographic studies were not carried out on the second crew.

Evaluating the physical work capability of the crews as a whole, one can say that that of the CDR-1 decreased less than in the crew which made a 63-day flight; in the OBE-1, it was approximately to the same degree as in this crew. The decrease in physical work capability of the members of the second crew did not differ from manifestations observed after preceding flights of similar duration and complexity.

Postural Loads

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As usual, after flight, the orthostatic stability of all the cosmonauts was decreased. It was a particularly pronounced decrease of orthostatic stability in members of the first crew.

After 15 hours after landing (immediately after the first night's sleep) the CDR-1 with great difficulty completed the active orthostatic test (standing in a position of "attention" for a period of five minutes). For the OBE-1, the test was stopped after one minute because of development of a pre-collapse state.

On the second day, a passive orthostatic test was conducted on a rotating table. For the OBE-1, it was stopped after 5 minutes due to the development a pre-collapse state (pallor, weakness, reduction of pulse, cold sweats). The results of studies of systemic blood circulation during the passive orthostatic tests are presented in Tables 12 and 13. Here the IIOS--the integral index of orthostatic stability, is given in conventional units: 100-86--outstanding stability, 85-71--good, 70-56--satisfactory, 55-41--decreased, 40 and less--poor.

The dynamics of recovery of orthostatic stability according to this integral index are presented in Figures 3 and 4.

Recovery of OS, like resistance to other load effects, occurred spasmodically. Then in the OBE-2 and particularly in the OBE-1, it recovered slowly. In the OBE-1, even at 36 days, the OS was noticeably decreased. The basic mechanism of poor transferability of the postural effect in him was disorder

TABLE 12. DYNAMICS OF MEAN VALUES OF BASIC INDICES OF SYSTEMIC BLOOD CIRCULATION DURING A PASSIVE-ORTHOSTATIC TEST.

	CDR -I						OBE -I					
	PREFLIGHT	DAYS POSTFLIGHT					PREFLIGHT	DAYS POSTFLIGHT				
		2	5	7	14	36		2 ^x	5	7	14	36
FCC	64	71	71	77	69	68	75	87	115	111	99	95
PE	220	220	220	202	220	231	208	160	172	190	189	184
AP _{lmb}	132	140	146	140	130	144	114	110	110	113	116	108
AP _m	95	106	104	110	99	103	90	85	92	91	91	91
AP _d	75	75	83	85	86	81	75	70	77	73	70	74
VM	9.3	10.2	10.8	9.7	10.8	10.3	7.8	9.5	8.7	7.0	9.8	9.2
V _e	8.4	7.4	7.0	8.1	9.9	8.5	7.5	5.6	6.6	6.4	6.9	6.1
SI	24	38	36	27	19	32	23	21	18	27	29	17
SyI	1.5	2.7	2.5	2.1	1.3	2.2	1.74	2.7	2.1	3.0	2.9	1.6
SPR	64	40	43	52	79	47	56	31	46	31	34	54
LIOS	96	83	90	91	90	97	77	19	61	61	68	66

NOTATION: SECOND VALUES OF INDICES PRESENTED FOR 5-MINUTE DP BEFORE TURNING IN A HORIZONTAL POSITION.

TABLE 13: DYNAMICS OF MEAN VALUES OF BASIC INDICES OF SYSTEMMIC BLOOD CIRCULATION DURING A PASSIVE ORTHOSTATIC TEST

INDICES	CDR-2					OBE-2				
	PREFLIGHT	DAYS POSTFLIGHT				PREFLIGHT	DAYS POSTFLIGHT			
		I	3	6	14		I	3	6	14
PCC	97	118	103	117	99	72	119	98	105	81
PE	190	162	196	170	178	205	168	188	178	200
AP _{lmb}	131	125	125	121	140	129	120	115	112	115
AP _m	101	104	100	92	110	99	98	94	99	95
AP _d	81	89	83	79	83	79	85	81	83	76
VM	930	946	800	930	930	1010	810	950	810	880
V _e	730	790	710	810	760	880	750	790	680	780
SI	22	13	29	17	25	25	17	18	17	21
SyI	2.14	1.58	3.0	2.0	2.5	1.8	2.0	1.8	1.8	1.7
SPR	47	66	33	46	46	58	49	53	55	56
TIOS	79	61	77	64	77	93	63	70	63	78

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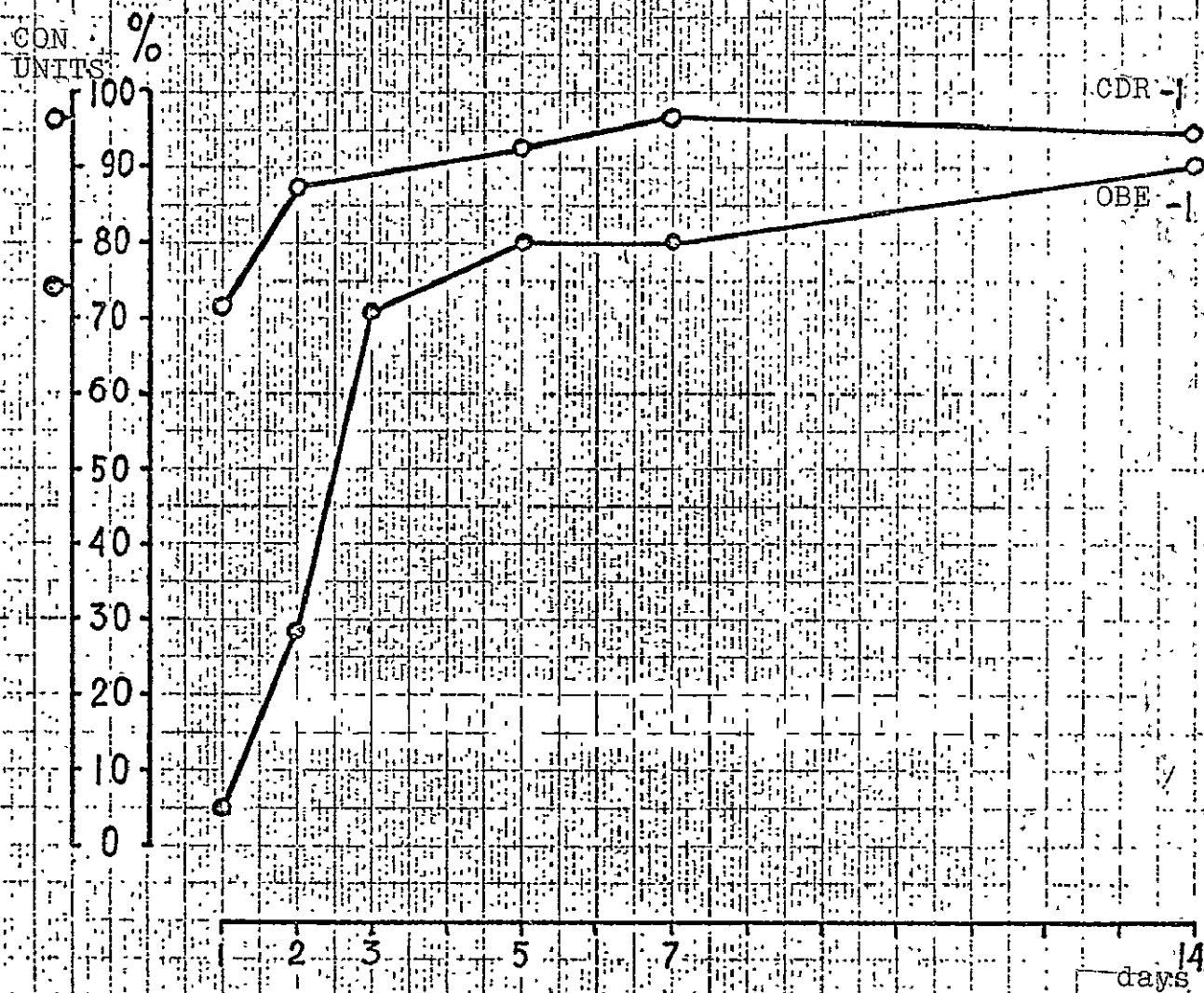


Figure 3. Dynamics of the integral index of orthostatic stability in cosmonauts after flight expressed in percentages of the preflight level (left scale).

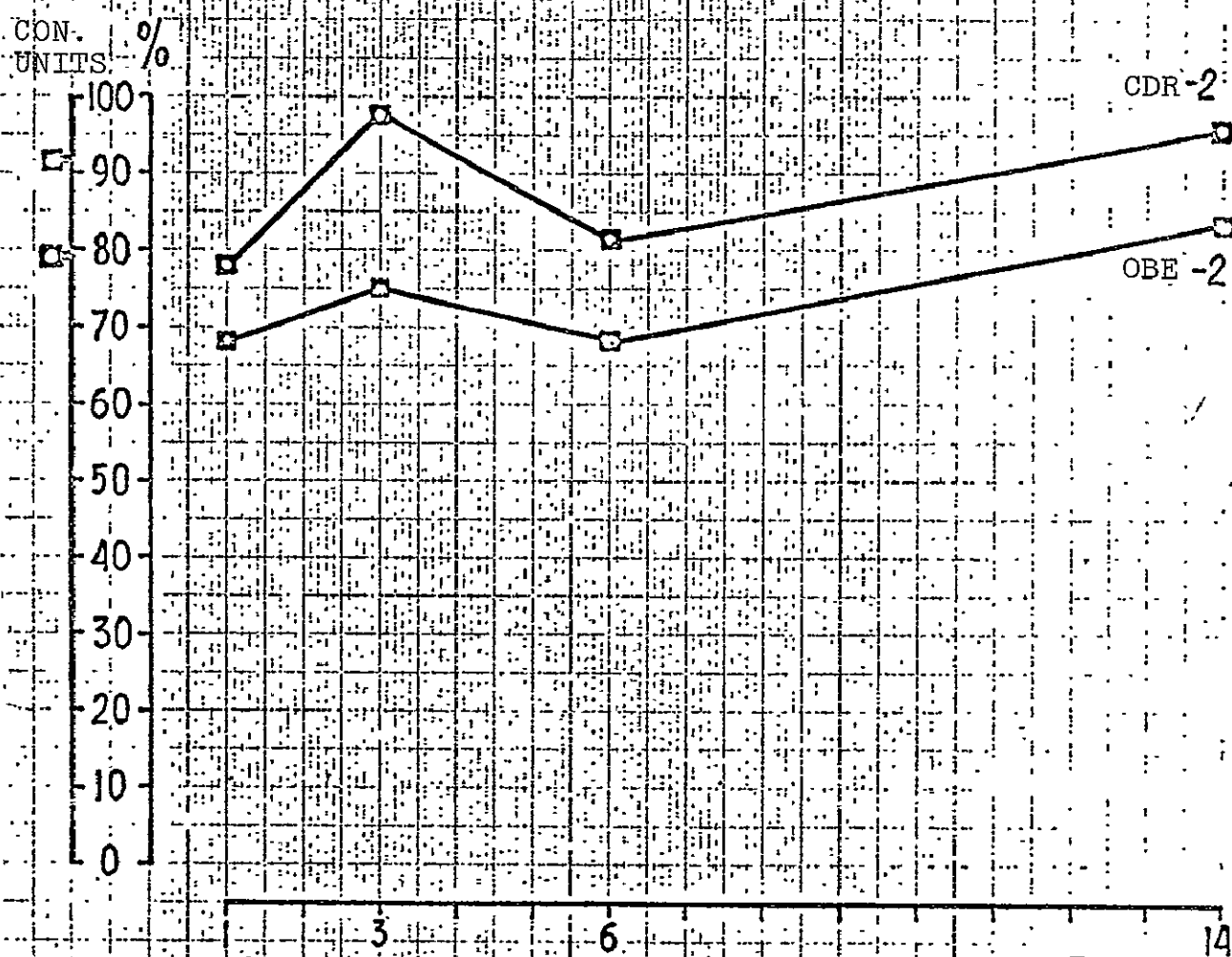


Figure 4. Symbols the same as in Figure 3.

of regulation of tonus of the arterial blood vessels and the vessels of the head. Apparently, changes occurring in flight in regulation of vascular tonus had been fairly stable in him.

Antiorthostatic Tests

The postural test lying in a position with the head below the feet is conducted in order to study restructuring of regulation of the vascular tonus of the head after flight for compensation of the redistribution of the blood in the upper half of the body. As is well known, in weightlessness one observes overfilling of the vessels of the chest, neck and head with blood; then, in the opinion of the cosmonauts, the feeling of fullness of the head with blood gradually decreases. It would be interesting to find out whether or not this only involves getting used to, that is, whether or not it is a purely subjective sensation or does the vascular tonus of the upper half of the body change decreasing the flow of blood in this area of the vascular channel.

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In preceding flights, it was pointed out that the tonus of vessels of the head increases. This made it possible to develop a special system of preflight training in order to "prepare" the vessels of the upper half of the body before the flight for the expected change in pressure. The indicated training is still optional, that is, an optimum regime has not yet been found.

The first crew trained very little (5--8 training periods) and the effect of training was very pronounced on the CDR-1 whose initial stability in an antiorthostatic position was lower than that of the OBE-1.

After the flight, many of the indices of the blood circulation system in an antiorthostatic position (AOP) became close to the indices in a horizontal position (HP), in particular, the stroke index, the mean lateral arterial pressure; besides this, the tonus of the vessels increased (Table 14). Then, these shifts are more pronounced in the OBE-1 in whom stability to AOP was higher in the preflight period than it was in the CDR-1. Such dynamics attest to restructuring of regulation of the blood circulation system directed at compensation of redistribution of blood to the head.

At the same time that the systemic hemodynamics gradually recover and after two weeks, it practically returns to the preflight level, reaction to AOP on day 5 was increased in comparison with day 1. Even on day 36, it was still pronounced. This attests to the fact that changes in regulation of blood circulation of the head after flight are more stable than changes in the systemic hemodynamics. Possibly, such stable changes of

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TABLE 14. CHANGE IN INDICES OF BLOOD CIRCULATION IN A HORIZONTAL POSITION IN A POSTURE TEST AND REACTIONS TO AOP -30°

	HORIZONTAL POSITION				$\frac{AOP}{HP} \times 100$			
	PREFLIGHT		CHANGE AFTER FLIGHT IN % OF PREFLIGHT VALUE		PREFLIGHT		DIFFERENCE BETWEEN POST-FLIGHT AND PREFLIGHT RATIOS OF THE INDICES	
	CDR-I	OBE-I	CDR-I	OBE-I	CDR-I	OBE-I	CDR-I	OBE-I
FCC	60	49	-7	+12	87	92	+11	+12
PE	270	290	+3	-11	111	107	-11	-4
AP _{lmb}	135	125	+3	+8	95	96	+7	-1
AP _d	70	75	+7	+6	100	97	-11	-3
AP _m	85	92	+1	+1	118	120	-10	-12
V _m	9.3	6.7	0	+5	87	106	+15	-2
V _e	5.6	5.6	+23	+7	91	100	+18	+5
SI	51	46	+4	+7	124	115	-16	-15
SPR	27	37	+33	0	96	100	-13	-14

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hemodynamics of the head involve not only functional but also morphological restructuring of the vessels.

In members of the second crew, stability toward AOP after flight changed insignificantly (Table 15).

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TABLE 15. CHANGE IN INDICES OF BLOOD CIRCULATION IN AN ANTI-ORTHOSTATIC POSITION OF A POSTURE TEST AND RELATIVE REACTION TO AOP ON DAY 1 POSTFLIGHT

	$\frac{AOP}{HP} - 30^0$				$\frac{AOP}{HP} \times 100$			
	PREFLIGHT		CHANGE AFTER FLIGHT IN % OF PREFLIGHT VALUE		PREFLIGHT		DIFFERENCE BETWEEN POST AND PREFLIGHT RATIO	
	CDR-2	OBE-2	CDR-2	OBE-2	CDR-2	OBE-2	CDR-2	OBE-2
FCC	76	59	+24	+34	99	100	+20	-10
PE	275	280	-9	-14	106	107	-2	-3
AP _{lmb}	133	132	-5	-3	102	102	-4	0
AP _d	78	78	+6	+3	104	98	-6	-4
AP _m	110	105	0	0	116	124	-2	-4
V _m	8.4	8.6	-5	-6	90	91	+3	-6
V _e	6.6	6.8	-5	-18	90	91	+10	-4
SI	39	49	-13	-16	106	132	+20	-8
SyI	3.0	2.9	+7	+14	107	132	+38	-18
SPR	32	32	-3	-3	94	71	-25	+21

In truth, they had a significantly shorter time period for flight and also a larger quantity of preflight training (24 for each cosmonaut). /44

This question requires further study, that is, one has not yet found the precise relationship between stability to AOP and clearness of the sense of fullness of blood in the head including such undesirable manifestations as headaches. At the same time, most of the cosmonauts report positively on training sessions for AOP and in the first days after flight preferred to sleep without pillows. During tests with AOP, they clearly indicate the angle of slope of the table at which the feeling of fullness in the head is comparable with the flight. From day to day this angle decreases in some earlier and in some later but usually after 5--7 days it is at zero.

Rheoencephalography

The dynamics of blood circulation in the head and also the condition of vessel tonus of the brain were traced using a REG.

In the CDR-1, postflight, the REG showed hypertension reactions. In the OBE-1, in whom the tonus of the vessels of the head in flight was singularly changed (see above), in the first days postflight, asymmetry of hyperemia and vascular tonus of the cerebrum hemisphere were observed on a background of total decrease of tonus of the head vessels. Recovery also had a sporadic character and on day 5, the changes indicated were even more pronounced than on the first day (Table 16 and 17).

LBNP

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As was indicated above, in the opinion of the cosmonauts, the test with negative pressure on the lower part of the body in flight transfers well. The reactions of the cardiovascular system to LBNP in the CDR-1 and CDR-2 was average: the frequency of cardiac contractions increased almost as it had pre-flight, arterial pressure was almost unchanged, stroke volume of blood was somewhat decreased (Tables 18 and 20).

In the OBE-1, transferability of the tests with LBNP in flight, decreased noticeably from test to test. This was noticeable with a more pronounced increase of FCC, a decreased stroke (and sometimes minute) volume of blood, and by a decreased pulse pressure (Table 19). Some limitation of compensatory possibilities of the cardiovascular system on LBNP was observed in him before flight.

Somewhat more marked than on Earth, with the reaction to LBNP in the OBE-2 on day 12 of flight (Table 21): a significant increase in the pulse rate, decrease in peripheral resistance of vessels and propagation of the pulse wave along the aorta.

After flight, on the day of landing, a decrease in

TABLE 16. DYNAMICS OF RHEOENCEPHALOGRAPHIC INDICES IN CONDITIONS OF OPERATIVE REST IN A LYING POSITION

INDICES	CDR-I					OBE-I					
	PREFLIGHT	DAYS POSTFLIGHT				PREFLIGHT	DAYS POSTFLIGHT				
		I	2	5	7		I	2	5	7	
A, MOM	l	I40	-	70	90	-	I10	I60	60	I50	I00
	r	I00	-	60	90	-	95	I20	70	60	75
C, MOM	l	I20	-	75	I00	-	I00	I20	50	I20	90
	r	I10	-	90	I20	-	95	90	50	40	80
PI,%	l	79	-	93	I00	-	80	63	50	60	70
	r	90	-	I42	I22	-	75	58	57	33	73
g-suit	l	88	-	59	73	-	78	84	45	88	70
conv. unit	r	78	-	63	80	-	73	68	47	41	62

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TABLE 17. DYNAMICS OF RHEOENCEPHALOGRAPHIC INDICES IN CONDITIONS OF OPERATIVE REST IN A LYING POSITION

INDICES		CDR-2					OBE-2						
		PREFLIGHT	0	I	3	6	I4	PREFLIGHT	0	I	3	6	I4
A, MOM	l	80		115	90	55	75	60		50	25	30	40
	r	55		65	60	70	65	60		50	75	60	60
C, MOM	l	65		110	105	45	65	70		50	40	40	50
	r	50		50	50	45	50	70		40	70	60	60
DI, %	l	50		65	100	45	53	100		75	148	117	100
	r	65		70	63	40	47	100		70	67	75	75
g-suit conv. unit	l	55		75	71	40	53	53		40	31	32	41
	r	44		44	44	43	45	53		36	54	46	49

TABLE 18. RESULTS OF TESTS WITH LBNP ON THE CDR-1 (VOLYNOV, B.V.)

TIME PERIOD	INDEX	BACK- GROUND	NEGATIVE PRESSURE, MM MERCURY COLUMN					RECOVERY MIN.				
			25	25	35	35	35	1	2	3	4	5
I	2	3	4	5	6	7	8	9	10	11	12	13
PREFLIGHT	FCC	54	53	53	55	55	55	53	51	53	51	51
	AP MIN.	67	68	66	67	68	70	63	64	66	63	60
	MID.	86	84	82	83	83	86	84	82	82	83	86
	LAT.	110	104	103	103	103	101	106	105	110	107	111
	LIMB	130	122	122	123	122	121	132	130	130	128	130
	PULS	43	36	37	36	35	31	43	41	44	44	51
	SV	102	89	91	86	80	68	102	97	105	104	120
	MV	5.5	4.7	4.9	4.7	4.4	3.7	5.4	5.0	5.5	5.3	6.2
IN-FLIGHT DAY 14	FCC	50	54	54								
	AP MIN.	70	71									
	MID.	96	100									
	LAT.	132	122									
	LIMB	153	143									
	PULS	62	51									
	SV											
	MV											
DAY 45	FCC	53	59	60	61	63	65	66	83			
	AP MIN.	67	70	68	70	65	66	65	65			
	MID.	92	95	95	97	98	99	106	95			
	LAT.	121	115	118	122	120	120	120	118			
	LIMB	147	140	135	145	146	140	145	152			
	PULS	54	45	50	52	55	54	55	53			
	SV											
	MV											
POSTFLIGHT DAY 0	FCC	55	53	52	55	54	53	52	50	66	49	49
	AP MIN.	53	53	53	52	54	55	50	54	52	53	53
	MID.	81	80	76	82	83	81	79	80	80	78	78
	LAT.	103	102	98	100	102	105	105	106	100	102	101
	LIMB	129	120	121	131	120	120	128	125	124	122	125

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I	2	3	4	5	6	7	8	9	10	11	12	13
PULS	50	49	45	48	48	50	55	52	48	49	48	
SV	103	103	102	105	105	104	119	120	121	114	116	
MV	5.7	5.5	5.3	5.8	5.6	5.5	6.2	6.0	8.0	5.6	5.7	
DAY 4	FCC	59	62	64	66	64	64	56	54	54	53	54
	AP MIN.	63	65	65	66	65	75	64	63	64	65	65
	MID.	90	94	84	89	89	96	92	88	83	92	95
	LAT.	113	112	95	100	102	114	112	118	110	121	114
	LIMB	132	128	116	125	120	122	145	138	128	130	132
	PULS	50	47	30	34	37	32	48	55	46	56	49
	SV	130	92	56	67	71	70	119	140	115	137	120
	MV	7.6	5.7	3.6	9.4	4.6	4.5	6.7	7.5	6.2	7.2	6.5
DAY 17	FCC	62	61	63	64	64	63	61	59	57	56	57
	AP MIN.	60	58	61	55	59	64	55	65	57	58	56
	MID.	93	94	92	90	95	94	90	93	98	94	94
	LAT.	115	110	110	105	105	109	112	120	118	116	115
	LIMB	142	133	130	122	132	130	146	141	150	145	142
	PULS	56	52	49	50	46	45	57	55	61	58	59
	SV	134	122	111	125	116	121	154	126	148	130	142
	MV	8.2	7.5	7.0	8.0	7.4	7.6	9.4	7.4	8.5	7.3	8.1

TABLE 19. RESULTS OF TESTS WITH LBNP ON THE OBE-1 (ZHOLOBOV, V.M.)

TIME PERIOD	INDEX	BACK- GROUND	NEGATIVE PRESSURE, MM-MERCURY COLUMN					RECOVERY MIN.				
			25	25	35	35	35	I	2	3	4	5
I	2	3	4	5	6	7	8	9	10	11	12	13
PRE- FLIGHT	FCC	43	43	47	48	48	47	46	41	47	43	43
	AP MIN.	54	51	56	57	54	60	53	53	52	52	53
	MID.	82	80	82	80	83	85	82	85	81	78	82
	LAT.	99	95	98	95	96	100	99	101	101	103	102
	LIMB	122	118	114	112	118	115	123	124	127	127	122
	PULS	45	44	42	38	42	40	46	48	49	51	49
	SV	124	101	103	87	91	87	128	124	131	133	129
	MV	5,3	4,3	4,9	4,1	4,4	4,1	5,9	5,1	6,1	5,7	5,6
IN- FLIGHT DAY 7	FCC	41	54	54	-	63	57					
	AP MIN.	48	47	-	-	50	-					
	MID.	42	83	-	-	78	-					
	LAT.	100	92	-	-	95	-					
	LIMB	132	128	-	-	113	-					
	PULS	52	45	-	-	45	-					
	SV	121	58	-	-	38	-					
	MV	5,0	3,1	-	-	2,4	-					
DAY 13	FCC	41	47	59	68	-	68					
	AP MIN.	51	50	53	55	60	53					
	MID.	87	84	90	98	-	98					
	LAT.	110	105	105	112	-	103					
	LIMB	137	127	123	125	-	-					
	PULS	59	55	52	57	-	50					
	SV	134	104	105	95	-	93					
	MV	5,6	4,9	6,2	6,4	-	6,3					
DAY 30	FCC	51	65	75	86	85	81					
	AP MIN.	50	-	49	-	49	48					
	MID.	80	-	82	-	85	87					
	LAT.	106	-	104	-	101	99					
	LIMB	140	-	123	-	123	122					
	PULS	56	-	55	-	52	51					
	SV	137	-	64	-	94	78					
	MV	7,0	-	4,8	-	7,9	6,3					

	I	2	3	4	5	6	7	8	9	10	11	12	13
DAY 44	FCC	58	73	77	95	88	-	56	55	60			
	AP MIN	57	57	56	56	57	-	63	58	60			
	MID	79	79	79	85	87	-	85	80	78			
	LAT	I08	I06	I05	I08	I05	-	I03	I04	I02			
	LIMB	I32	I25	I28	I25	I28	-	I32	I25	I30			
	PULS	51	49	49	52	48	-	40	46	42			
	SV	I21	91	80	91	73	-	83	89	98			
	MV	7,0	6,6	6,2	8,6	6,5	-	4,7	4,9	5,9			
POST- DAY 4	FCC	52	62	65	69	71	68	53	50	47	50	51	
	AP MIN	62	60	66	68	66	70	66	64	65	62	60	
	MID	92	89	94	98	96	96	93	97	93	92	95	
	LAT	112	110	107	108	106	110	120	118	115	112	114	
	LIMB	I38	I28	I26	I21	I25	I28	I40	I40	I42	I40	I36	
	PULS	50	50	41	40	40	40	54	54	50	50	54	
	SV	I62	118	80	71	76	68	I54	I65	I54	I53	I71	
	MV	8,3	7,3	5,2	4,9	5,4	4,5	8,2	8,2	7,3	7,7	8,7	
DAY 17	FCC	65	76	78	92	85	84	75	66	65	65	62	
	AP MIN	55	57	62	62	60	62	59	56	56	54	53	
	MID	77	75	82	81	82	84	81	80	78	78	75	
	LAT	99	96	98	99	100	96	102	103	101	105	103	
	LIMB	114	114	118	128	112	114	122	130	130	124	126	
	PULS	44	39	36	37	40	34	43	47	45	51	50	
	SV	I03	70	65	54	71	65	I05	I02	97	110	I06	
	MV	6,6	5,3	5,1	5,0	6,0	5,5	7,9	6,7	6,3	7,1	6,7	

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TABLE 20. RESULTS OF A TEST WITH LBNP ON THE CDR-2 (GORBATKO, V.V.)

TIME PERIOD	INDICES	BACK- GROUND	NEGATIVE PRESSURE-MM MERCURY-COLUMN					RECOVERY MIN				
			25	25	35	35	35	1	2	3	4	5
PRE- FLIGHT	FCC	78	94	92	97	96	92	82	75	74	75	70
	AP MIN.	69	67	69	78	79	79	68	72	69	69	66
	MID.	94	87	88	104	95	95	97	94	90	94	99
	LAT.	108	98	103	118	113	110	117	112	110	110	111
	LIMB	146	125	132	138	145	145	150	150	145	142	142
	PULS	39	31	34	40	34	31	49	40	41	41	45
	SV	83	44	45	49	43	37	104	86	81	83	91
	MV	6.5	4.2	4.2	4.7	4.1	3.4	8.5	6.5	6.0	6.2	6.4
IN- FLIGHT DAY 13	FCC	69	84	80	91	85	82	70	67	64	-	81
	AP MIN.	62	-	63	68	65	67	62	60	60	-	67
	MID.	93	-	96	94	95	92	92	86	90	-	92
	LAT.	109	-	107	109	110	110	113	115	110	-	108
	LIMB	152	-	139	135	135	135	135	140	142	-	140
	PULS	47	-	44	41	45	43	51	55	50	-	41
	SV	106	-	85	76	85	85	102	105	100	-	82
	MV	7.3	-	6.8	6.9	7.2	7.0	7.1	7.0	6.4	-	6.6
POST- FLIGHT DAY 0	FCC	84	102	96	98	103	101	74	69	75	82	74
	AP MIN.	65	67	74	73	72	78	69	72	70	70	71
	MID.	91	92	94	90	91	98	95	95	90	96	90
	LAT.	106	105	103	101	104	106	117	110	110	109	109
	LIMB	144	137	128	130	133	127	150	152	146	144	148
	PULS	41	38	29	28	32	28	38	38	40	39	38
	SV	86	57	40	40	44	40	76	83	90	86	79
	MV	7.2	5.8	3.9	3.9	4.6	4.0	5.6	5.8	6.7	7.0	5.8
DAY 11	FCC	97	104	103	101	115	106	89	90	97	96	96
	AP MIN.	69	68	72	73	74	71	72	70	68	66	67
	MID.	97	98	97	96	99	94	103	102	104	100	103
	LAT.	110	106	105	107	113	111	120	115	116	117	120
	LIMB	144	143	143	138	140	142	155	152	156	152	148
	PULS	41	38	33	34	39	40	48	45	48	51	53
	SV	96	61	50	44	49	49	103	104	109	108	120
	MV	9.2	6.4	5.2	4.4	5.6	5.2	9.2	9.4	10.4	10.3	11.5

TABLE 2D. RESULTS OF A TEST WITH LBNP ON THE OBE-2 (GLAZNOV)

TIME PERIOD	INDICES	BACK-GROUND	NEGATIVE PRESSURE MM-MERCURY COLUMN					RECOVERY MIN.				
			25	25	35	35	35	1	2	3	4	5
PRE-FLIGHT	FCC	55	56	54	54	56	50	55	55	53	54	50
	AP MIN.	59	56	58	57	59	56	63	65	65	63	70
	MID.	86	88	83	84	85	89	85	86	84	85	92
	LAT.	98	97	93	97	97	99	104	98	98	103	105
	LIMB	134	125	125	126	126	126	133	131	136	128	133
	PULS	38	41	35	40	38	43	41	33	33	40	35
	SV	99	97	80	96	94	117	120	89			
IN-FLIGHT DAY 12	MV	5.5	5.4	4.3	5.2	5.3	5.8	6.6	5.0			
	FCC	78	86	82	91	114	114					
	AP MIN.	65	62	63	60	61	61					
	MID.	99	95	99	96	98	96					
	LAT.	117	109	113	108	115	114					
	LIMB	150	142	145	142	144	145					
	PULS	52	47	50	48	54	53					
POST-FLIGHT DAY 01	SV	138	-	113	101	107	106					
	MV	10.8	-	9.2	9.2	12.2	12					
	FCC	78	86	81	95	94	95	69	72	72	65	71
	AP MIN.	88	73	77	75	69	71	77	73	75	75	75
	MID.	101	99	95	94	104	95	108	100	103	100	109
	LAT.	113	110	106	109	112	109	118	118	117	111	118
	LIMB	141	133	136	138	136	132	155	152	153	142	142
DAY 4	PULS	39	37	29	34	43	38	41	45	42	36	43
	SV											
	MV											
	FCC	69	86	86	85	92	86	80	73	64	70	69
	AP MIN.	70	71	71	74	74	73	67	70	69	69	65
	MID.	95	102	102	98	102	103	93	99	98	105	96
	LAT.	109	110	108	104	111	114	115	111	112	119	119
	LIMB	143	133	132	128	135	141	150	142	145	146	143
	PULS	39	39	37	30	37	41	48	41	43	50	44
	SV	111	101	101	71	103	102	142	120	120	135	135
	MV	7.6	8.7	8.7	6.0	9.5	8.7	11.3	8.8	7.7	9.4	9.3

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transferability of LBNP was noted in all the cosmonauts and a parallel to orthostatic stability was detected. Like worsening of orthostatic stability the decrease in transferability of LBNP was particularly marked in the OBE-1. It remained fairly marked in him even on day 17 postflight.

In the OBE-2, the transferability of LBNP was decreased up until the end of the first week. On day 14, full recovery had practically occurred both in the CDR-1 and the CDR-2.

Results of Clinical and Biochemical Studies

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When carrying out clinical and biochemical studies the same changes were found which were observed earlier in other crews of orbital space stations.

In blood taken during cosmic flight on days 9, 17 and 38, a certain decrease in the ratio of leukocytes per 1000 erythrocytes was noted basically due to elements of brain hemopoiesis (neutrophils and basophils). At the same time, a decrease in the quantity of thrombocytes was noted (by 10-15%) and the number of reticulocytes was more noticeable (up to 25-40%).

Studies of the blood taken after 3-8 hours after landing showed a decrease in the size of the hematocrit in the second crew and an increase in the first crew. The quantity of reticulocytes and eosinophils decreased almost by half, the thrombocytes by 7-9%. The number of erythrocytes was somewhat increased (obviously, due to a certain thickening of the blood) and the amount of hemoglobin changed somewhat differently in different cosmonauts (Figure 5).

In the succeeding days, the readaptation period, the content of hemoglobin in the peripheral blood and the mass of hemoglobin in the organism gradually decreased up to days 14-15 (Figures 6 and 7). The size of the hematocrit in the first crew members began to recover in the second week; in the second crew it was only in the third week postflight. The number of erythrocytes, after the first week, began to increase and the number of reticulocytes in this time period reached a maximum, that is, a pronounced post-flight reticulocytosis was observed (Figure 5). Then, with a shift left (full-reticular and powdered cells), this attests to irritation of the brain.

The picture of changes of the hemoglobin and cellular elements, especially the reticulocyte, contribute well to the hypothesis that due to the effect of factors of space flight, the rate of synthesis of hemoglobin was decreased and, correspondingly, the mass of circulating blood was decreased. In the period of readaptation on Earth, the reactive increase in the rate of synthesis of hemoglobin and erythropoiesis ensued. Due to the

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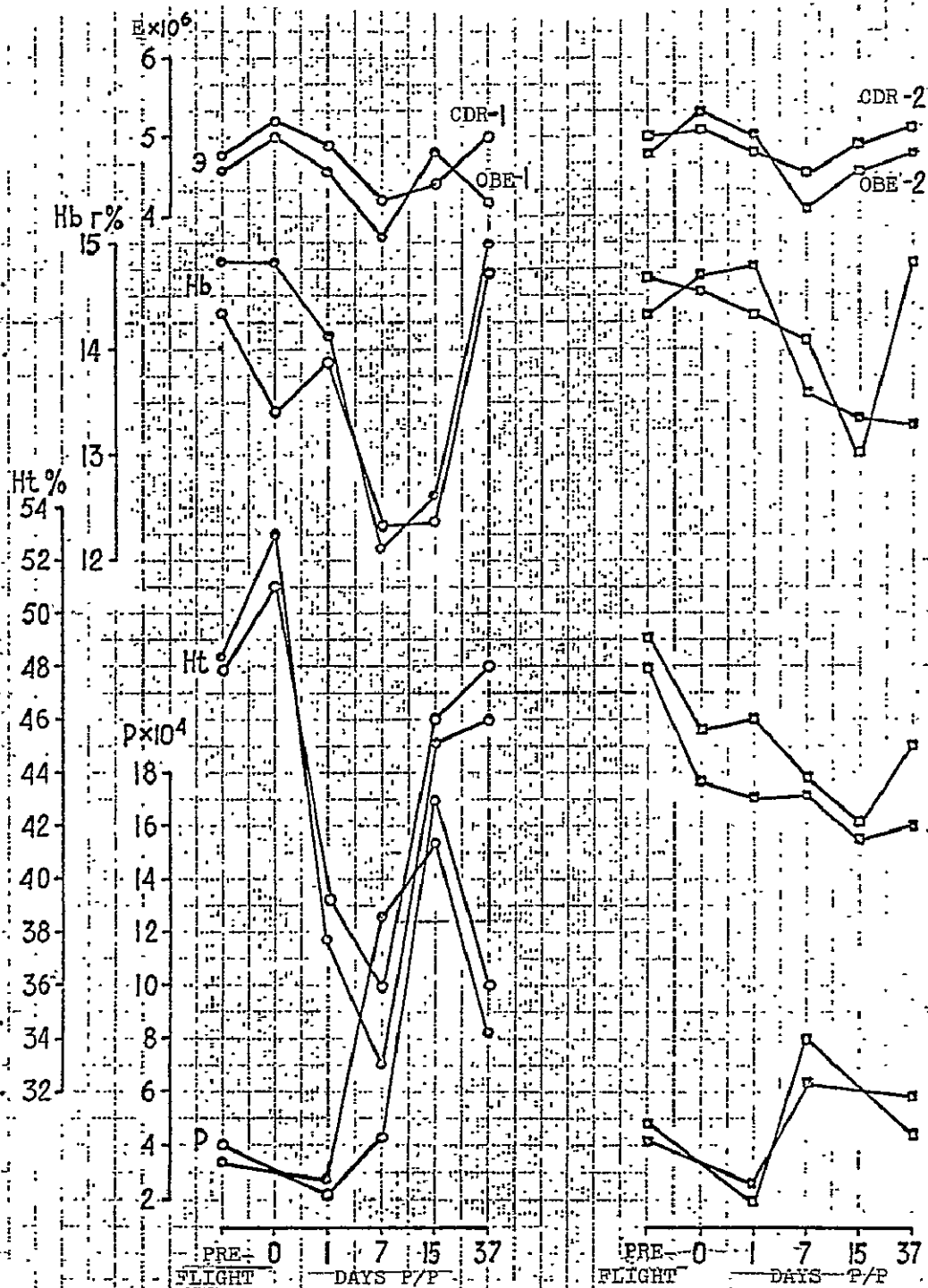


Figure 5. Dynamics of hematological indices: in the crews of the OPS, the Salyut-5 pre and postflight, along the axis of the ordinate: Hb--amount of hemoglobin in the blood in g%, E--number of erythrocytes in a μ l of blood, Ht--size of the hematocrit/whole-crit/in%, P--number of reticulocytes in a ml of blood.

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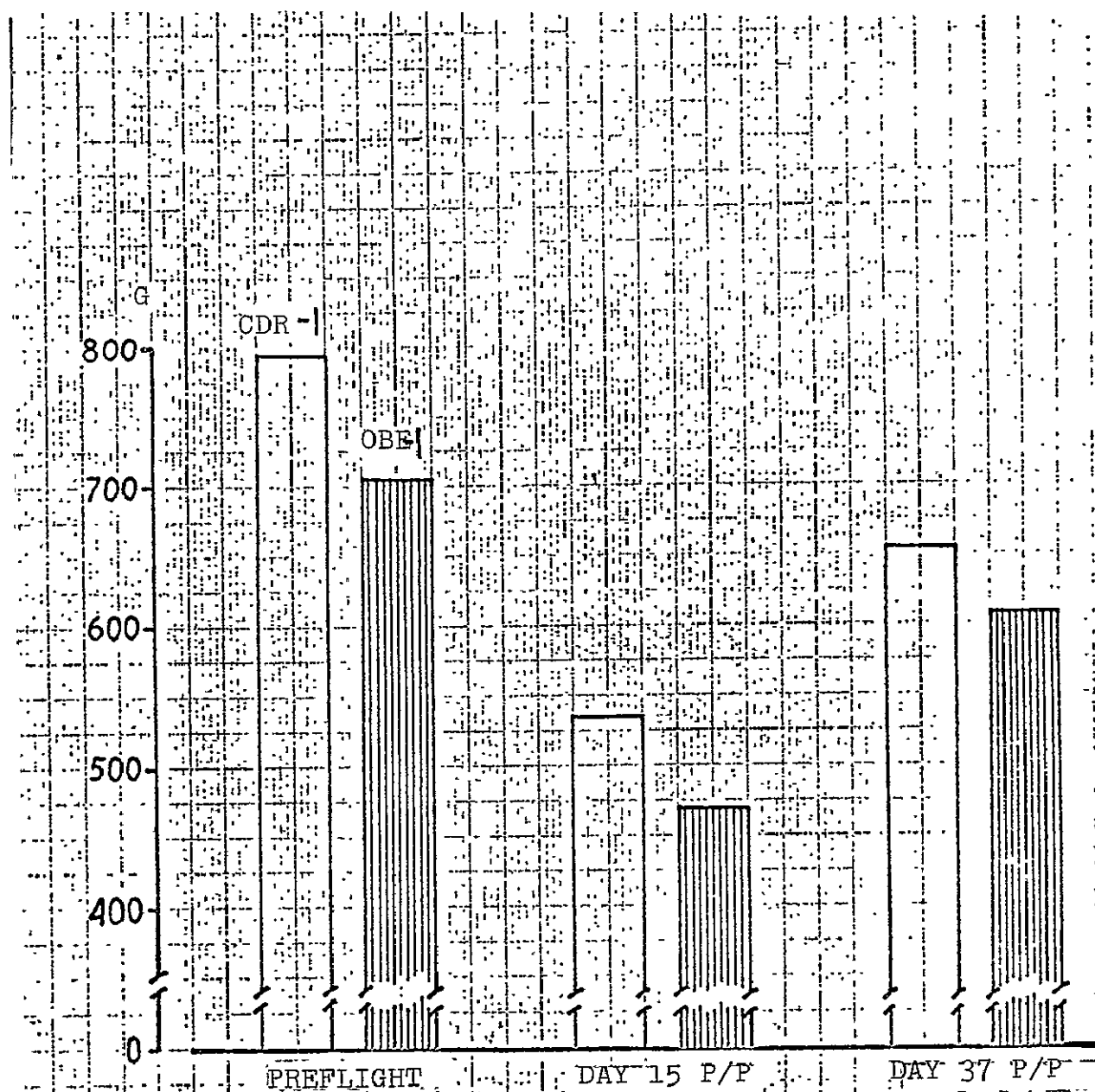


Figure 6. Mass of hemoglobin in crewmembers of the Soyuz-21-Salyut-5, postflight.

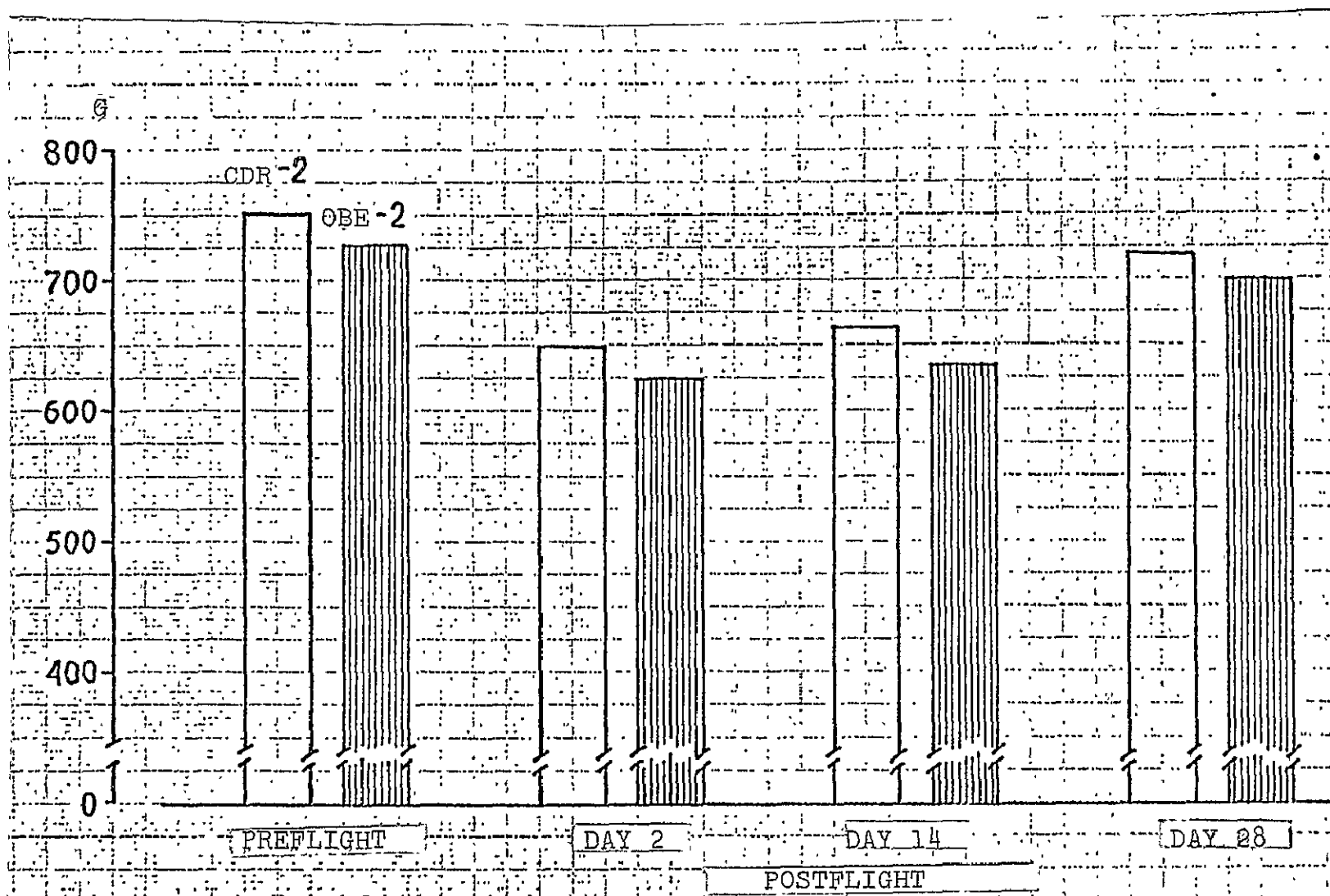


Figure 7. Mass of hemoglobin in members of the Soyuz-24 crew, postflight

delay in synthesis of the hemoglobin in meeting the requirements of the organism for blood, the "reserves" - young reticulocytes were ejected. Normalization of the Price-Jones blood and certain hematological indices ensued in week 3-4 and of others only after 1.5-2 months.

From the large number of indices studied, one should pay attention to the decrease in cholesterol in the CDR-2 and OBE-2 (by 9 % and 7%), and also to the increase on the first days of activity of muscular and hepatic enzymes (Figures 8, 9 and 10). Also the results of thymol tests were increased. Studies of the activity of isoenzymes 1 and 5 (cardiac and liver) of lactic dehydrogenases in members of the second crew showed their large relative increase in comparison with the total LDH, that is, the increase in activity of total LDH occurred due to isoenzymes. In the CDR-2, the shift of isoenzyme 5 (hepatic) was more pronounced and in the OBE-2--the cardiac enzyme.

At the same time, like the activity of the PC after a week, the LDH normalized after 2--3 weeks; the activity of sorbitodehydrogenase (SDH) continued to increase and on day thirty reached a size of 1.3-1.8 unit/ml. It is not impossible that after 14 days of the readaptation period, certain changes in the activity of the enzymes were due not only to the effect of space flight factors but also to disruption of the diet regime.

As was already pointed out, recovery of body weight occurred rapidly in the first 3-5 days (about 64%), and later on recovery was slower and took more than two weeks; in some of the cosmonauts it took more than a month. This, apparently, is due to atrophy /63 of muscular and other tissue in flight; the increase in the total blood proteins and the increase in the concentration of residual nitrogen in the blood indicates this.

Also, excretion of total nitrogen, phosphorus, sulphur, calcium, potassium, etc. from the urea increased. This all, undoubtedly, is due to change in metabolism of separate organs and tissues. We are reminded that after space flights, usually the content of cholesterol in the blood is decreased (sometimes by as much as 20%). In contradiction to this, in members of the second crew, the content of cholesterol in the blood was almost twice as high as preflight (243.5 mg % in comparison with 124.0 mg % preflight).

One should note that in these cosmonauts, in the first days postflight, that proteins (Figure 11) granular and hyaline cylinders, cells of the renal epithelium and erythrocytes were all observed in significant quantity in the urine, that is, symptoms of nephropathy were apparent. It is possible that this

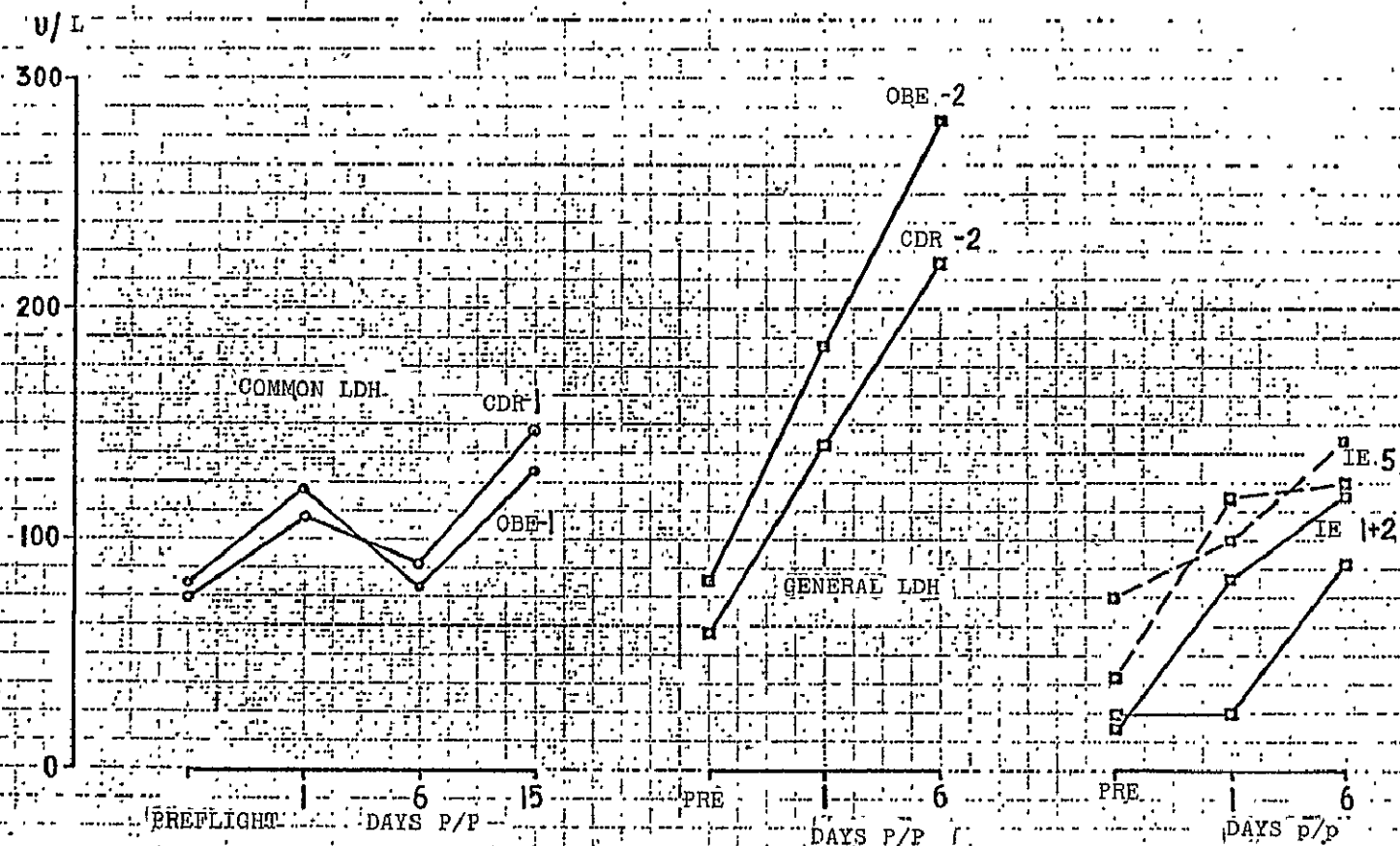


Figure 8. Activity of general lactic dehydrogenases (LDH) and isoenzymes 1 + 2 and 5.

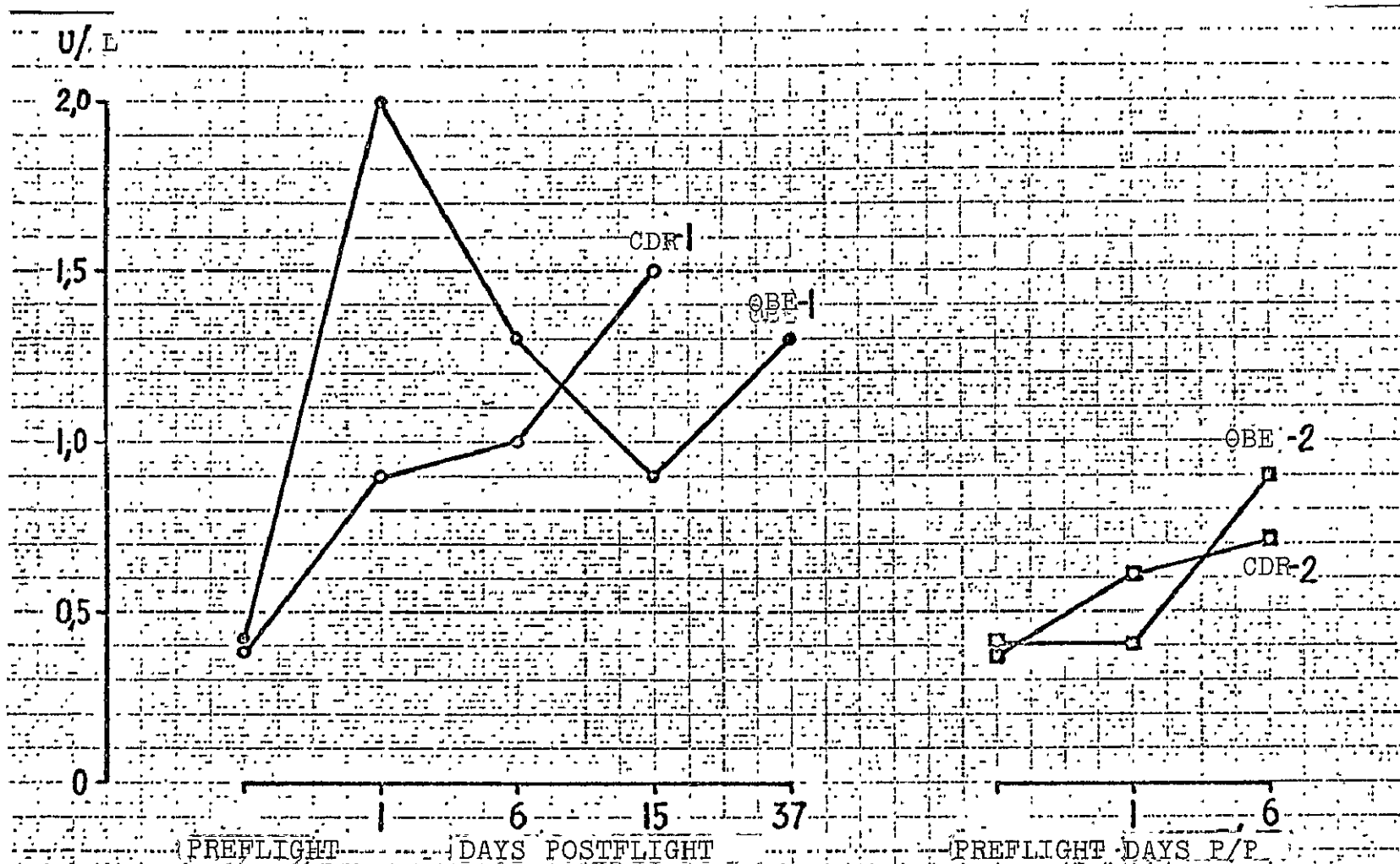


Figure 9. Activity of sorbitodehydrogenases (SDH).

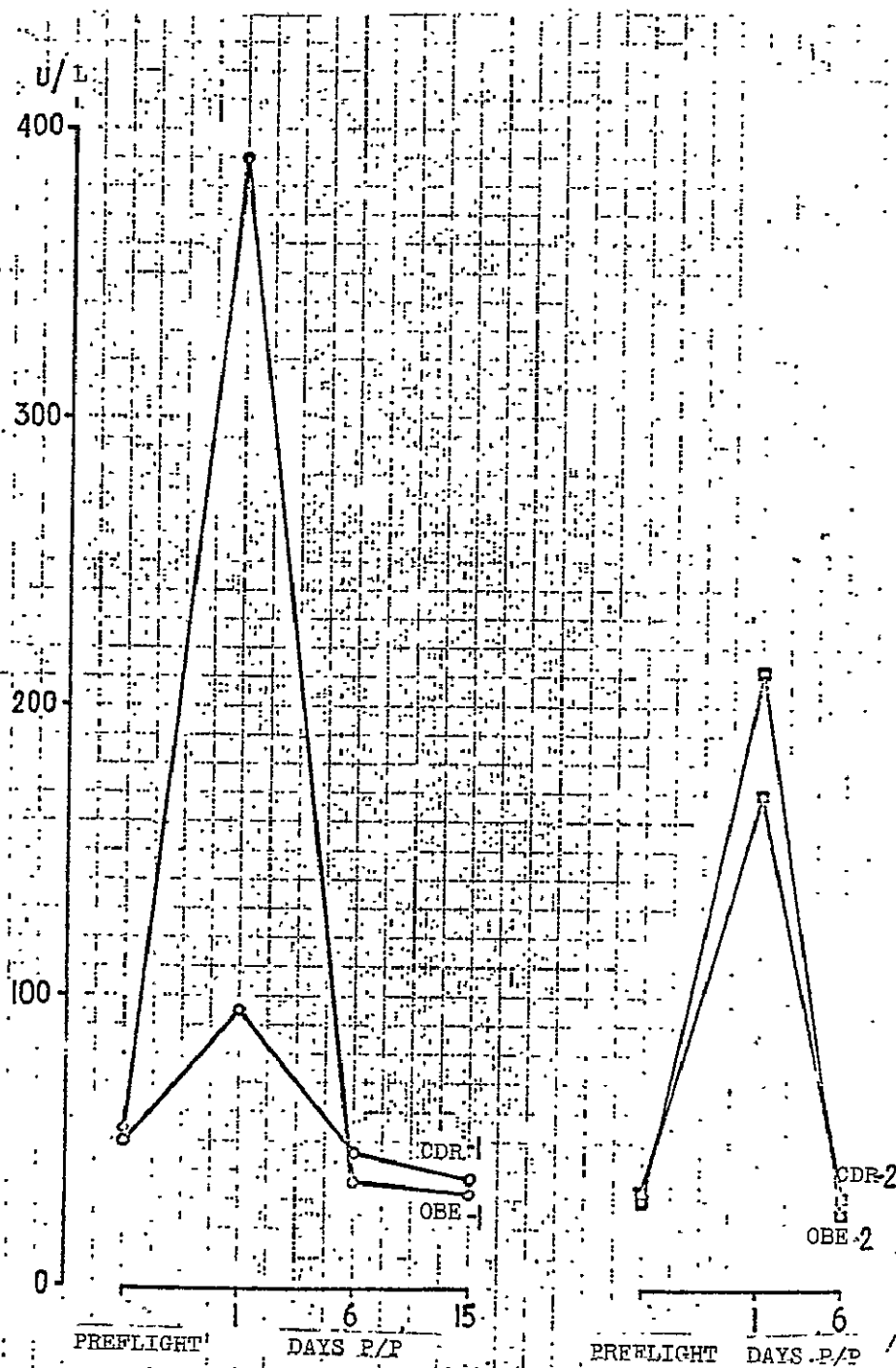


Figure 10. Phosphocreatinase activity (PC).

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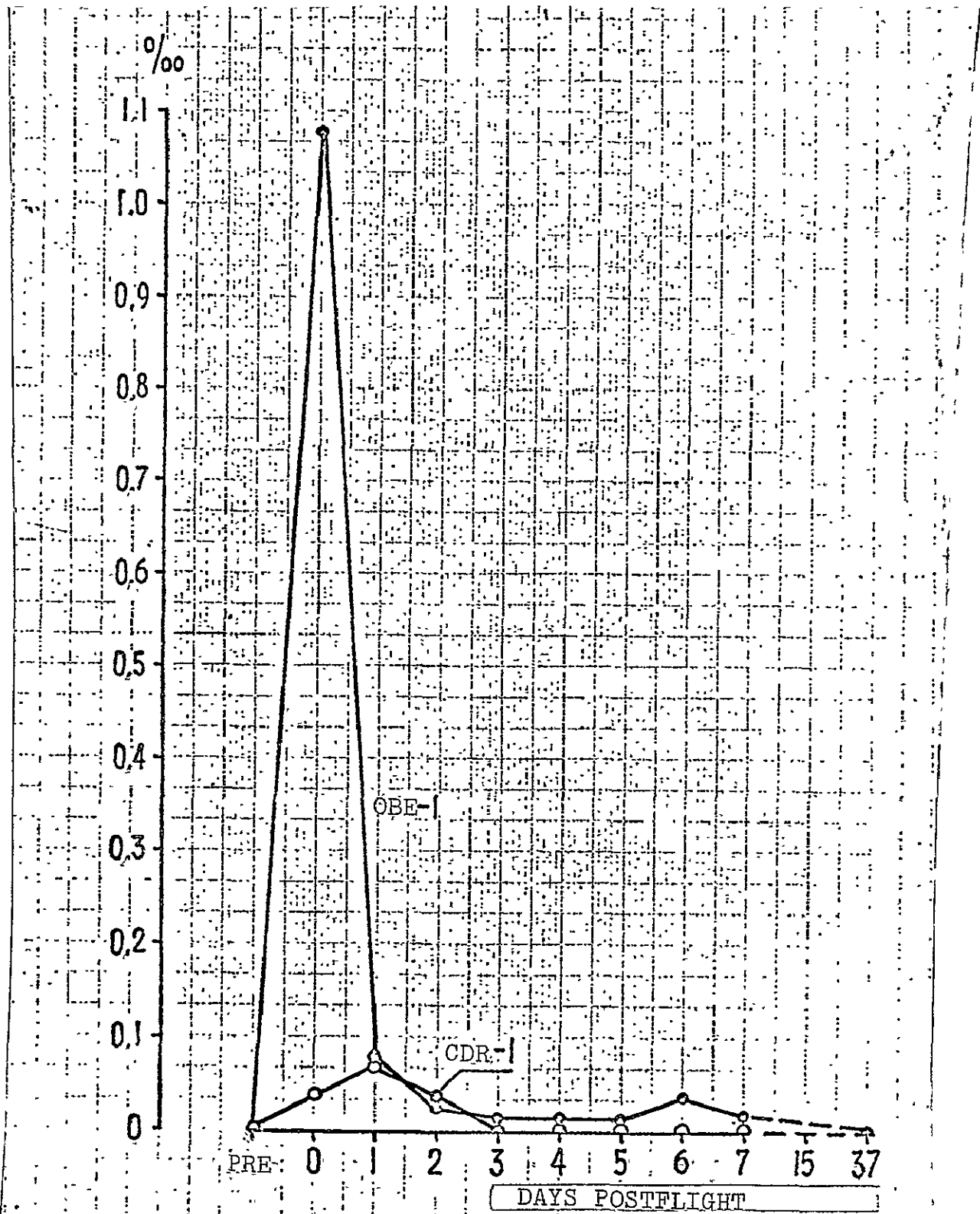


Figure 11. Dynamics of albuminuria in the crews of the Salyut-5--Soyuz-21, postflight.

is closely connected to the increase in cholesterol in them.

The dynamics of generation of urine in the CDR-1 and OBE-1 in the first postflight days indicate that diurnal and nocturnal diuresis are almost identical (Figure 12) particularly in the OBE-1. This relationship indirectly supports the changes noted above in the cardiovascular system.

Excretion of epinephrine and noradrenaline increased to the upper limits of the norm and in the first days the content of aldosterone was increased. Generation of 17-oxicorticosteroids was within ordinary limits, but the relationship of separate fractions was changed. Marked changes in the nitrogen components were not observed. These studies also are new and therefore are not adequate statistically.

Study of corticosteroids of the urine using a thin-layer chromatograph indicated an increase in the specific quantity of predominant glucocorticoid hormones on a background of decreased generation of non-metabolized steroids; this is involved with the relative functional inadequacy of the adrenal cortex in developing steroid hormones.

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Immunological Studies

After the flight, in all of the cosmonauts, as before, one observed a certain decrease in total and local immunological resistance of the organism. Restructuring of the microbe flora occurred, simplifying it, but at the same time, the number of complex-pathogenic strains increased. A decrease and elimination of lactobacilli and bacteroides was observed in the mouth cavity and in the intestine, and also the appearance of intestinal flora in the mouth cavity was observed. At the same time, the content of intestinal bacilli and enterococci in the intestine decreased.

In the first crew members, a positive reaction was noted to the C- reactive protein. In members of the second crew, this reaction was negative.

M. The content of immunoglobulins was increased, especially G, A, and M. Obviously, in connection with atrophic changes in the skeletal musculature and muscles of the heart in the CDR-2, antibodies for the myocardium were found, that is, an auto-immunological process was observed. In members of the second crew, at the end of the fourth week, (by day 28) and in the first crew on day 37 (according to immunoglobulins A), the immune system was reestablished.

In this way, the results of the medical observations in

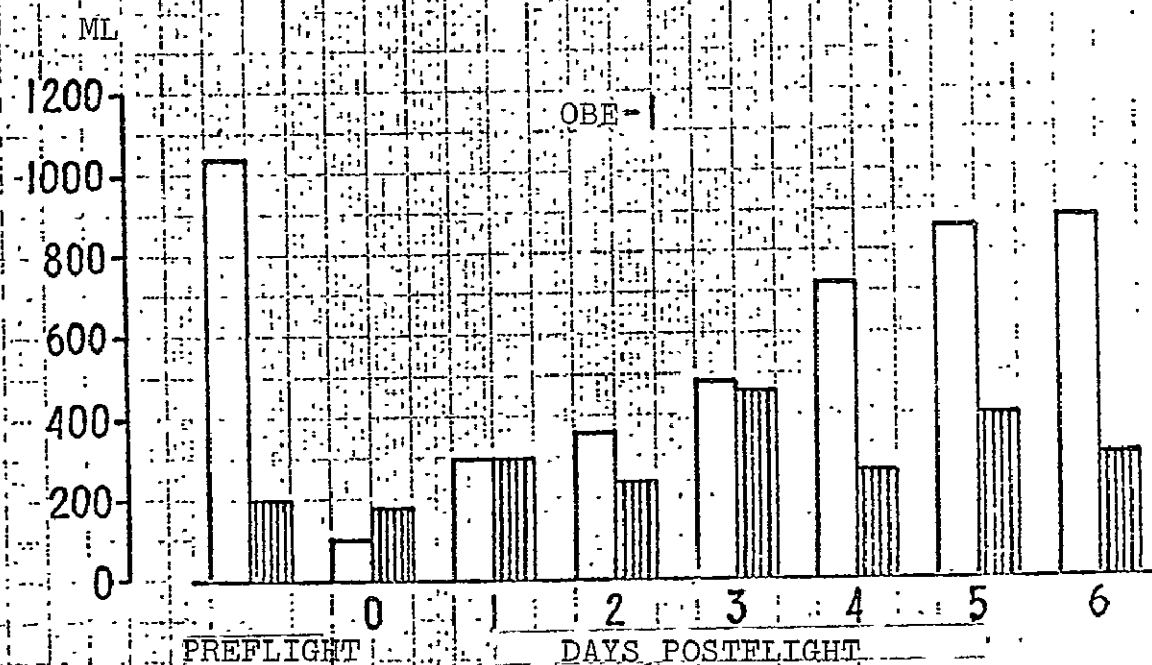
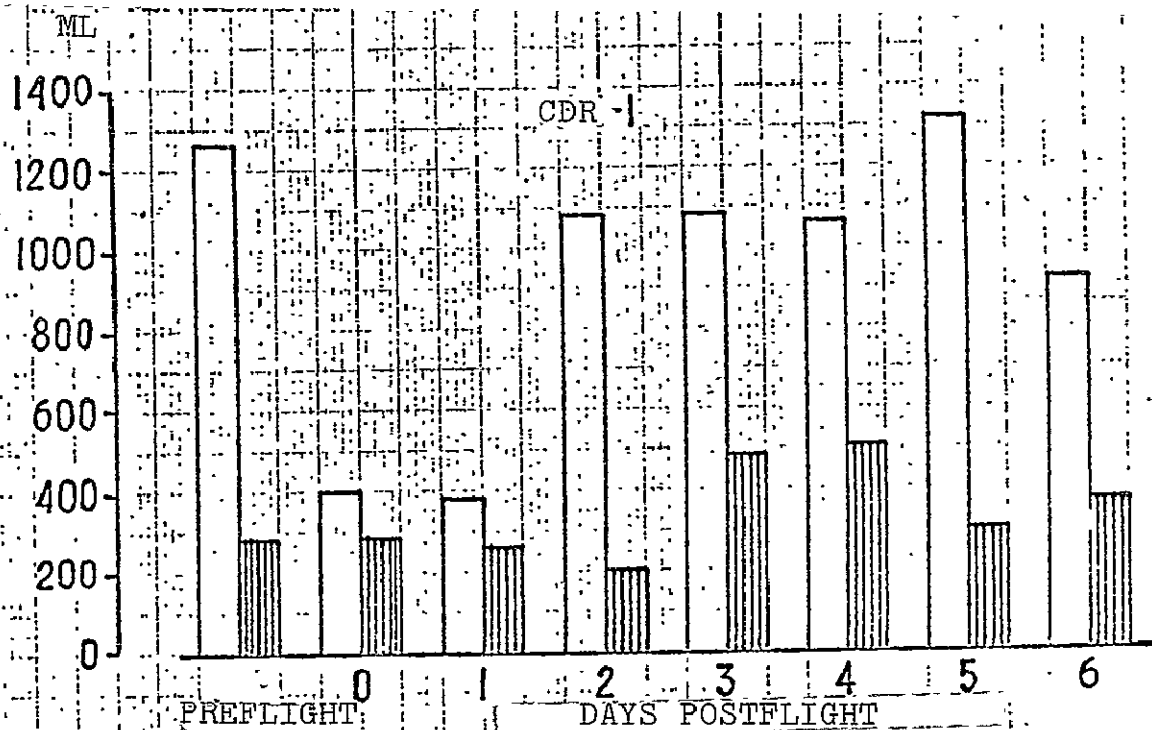


Figure 12. Dynamics of urine generation in the members of the Salyut-5 crew. Along the axis of the abscissa: 0--zero days; the number (+)--days postflight, along the ordinate axis: indices of diuresis in ml.

□ - DAY ▨ - NIGHT

studies made when preparing and accomplishing flights on the Salyut-5 orbital station, and also during the postflight observation of the cosmonauts, many data and general principles were supported which had been obtained in previous flights. Also, new facts were obtained relating to reactions of long-term effect of physical factors of space flight, living conditions and stressful work activity. This brought about certain changes in the research program including the program of medical observations after flight. /6.7

The conclusion drawn earlier as to significant restructuring of the functional systems due to factors of space flight (particularly weightlessness) can be considered correct as a whole. A decrease in the reserve capabilities of the organism in flight was proven and the importance of strict observation of the work and rest regime was convincingly demonstrated as well as carrying out fully the planned physical exercises.

However, any questions require further, deeper and more detailed studies in order to increase safety of space flights, improve working conditions for crewmembers of spacecraft and space stations, maintain health of the cosmonauts as well as their professional work capability.